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# A HANDBOOK OF CLIMATIC TREATMENT

# A HANDBOOK

OF

# CLIMATIC TREATMENT

INCLUDING

# BALNEOLOGY

BY

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# PREFACE

THE chief aim of this book is to place the therapeutics of climate on a secure foundation. With this view the physiology of climate is very fully dealt with; and it yields an adequate basis for a new Classification of Climates. This new classification is especially fitted for the needs of the physician.

A concise account of Meteorology, or the factors of climate, from a medical standpoint, precedes the physiological discussion. The well-known works of Buchan, Scott, Hann, Mohn, van Bebber, and Renk have been freely used.

Another aim of the book is to enable the physician readily to master the principles of choice in the selection of Baths and Mineral Waters. With this object a therapeutic classification has been adopted. In this portion of the subject the works of Kisch and of Reimer, and especially the encyclopedic *Lehrbuch* of Glax, have been my constant friends.

The materials here put together have been steadily collected during many years. They represent, in addition to the sources of information cited in the references, much

valuable knowledge generously and pleasantly given by my medical brethren in various parts of the world.

My thanks are due particularly to Dr. Frank Wyatt-Smith of Woking for an excellent manuscript with maps, which he prepared during his residence in South Africa. To my colleague, Dr. A. F. Bill, I am indebted for helpful criticism and for aid in calculations.

*October* 11, 1905.

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## CHAPTER LII

# MEMORANDA

## Air

1 litre of dry air at 0° C. and 760 mm. = 1·293 grammes.
1 gramme ,, ,, = 773 cubic centimetres.

## Water-Vapour

Specific gravity (air as unity) 0·6225.
1 gramme per cubic metre = 1 grain per 2·29 cubic feet.
= 0·44 grain per cubic foot.

## Carbonic Dioxide, $CO_2$

Specific gravity (air = 1) 1·529.
1 gramme at 0° C. and 760 mm. = 505·5 cubic centimetres.
1 litre ,, ,, = 1·977 grammes.

## Sulphuretted Hydrogen, $H_2S$

Specific gravity (air = 1) 1·1912.

## Rate of Expansion of Gases with Heat

$= \frac{1}{273}$ of volume or 0·0037 for each degree centigrade. *E.g.* Air in passing from 0° C. to 27° C. increases in volume by one-tenth.

3 cubic inches = 49 ccm.
1 ,, = 16·38 ccm.
1 cubic inch per gallon = 3·6 ccm. per litre.
1 grain ,, ,, = 0.014 grammes per litre.
1 gramme per litre = 70 grains per gallon.

Comparison of the Centrigade Thermometer with Fahrenheit's and Reaumur's, giving the Corresponding Values for each Degree, from + 50° to − 41° Centrigade.

From A. Buchan's *Introductory Text-Book of Meteorology.*

| Cent. | Fahr. | Reau. | Cent. | Fahr. | Reau. | Cent. | Fahr. | Reau. | Cent. | Fahr. | Reau. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| 50 | 122·0 | 40·0 | 27 | 80·6 | 21·6 | 4 | 39·2 | 3·2 | − 19 | − 2·2 | − 15·2 |
| 49 | 120·2 | 39·2 | 26 | 78·8 | 20·8 | 3 | 37·4 | 2·4 | − 20 | − 4·0 | − 16·0 |
| 48 | 118·4 | 38·4 | 25 | 77·0 | 20·0 | 2 | 35·6 | 1·6 | − 21 | − 5·8 | − 16·8 |
| 47 | 116·6 | 37·6 | 24 | 75·2 | 19·2 | 1 | 33·8 | 0·8 | − 22 | − 7·6 | − 17·6 |
| 46 | 114·8 | 36·8 | 23 | 73·4 | 18·4 | 0 | 32·0 | 0·0 | − 23 | − 9·4 | − 18·4 |
| 45 | 113·0 | 36·0 | 22 | 71·6 | 17·6 | − 1 | 30·2 | − 0·8 | − 24 | − 11·2 | − 19·2 |
| 44 | 111·2 | 35·2 | 21 | 69·8 | 16·8 | − 2 | 28·4 | − 1·6 | − 25 | − 13·0 | − 20·0 |
| 43 | 109·4 | 34·4 | 20 | 68·0 | 16·0 | − 3 | 26·6 | − 2·4 | − 26 | − 14·8 | − 20·8 |
| 42 | 107·6 | 33·6 | 19 | 66·2 | 15·2 | − 4 | 24·8 | − 3·2 | − 27 | − 16·6 | − 21·6 |
| 41 | 105·8 | 32·8 | 18 | 64·4 | 14·4 | − 5 | 23·0 | − 4·0 | − 28 | − 18·4 | − 22·4 |
| 40 | 104·0 | 32·0 | 17 | 62·6 | 13·6 | − 6 | 21·2 | − 4·8 | − 29 | − 20·2 | − 23·2 |
| 39 | 102·2 | 31·2 | 16 | 60·8 | 12·8 | − 7 | 19·4 | − 5·6 | − 30 | − 22·0 | − 24·0 |
| 38 | 100·4 | 30·4 | 15 | 59·0 | 12·0 | − 8 | 17·6 | − 6·4 | − 31 | − 23·8 | − 24·8 |
| 37 | 98·6 | 29·6 | 14 | 57·2 | 11·2 | − 9 | 15·8 | − 7·2 | − 32 | − 25·6 | − 25·6 |
| 36 | 96·8 | 28·8 | 13 | 55·4 | 10·4 | − 10 | 14·0 | − 8·0 | − 33 | − 27·4 | − 26·4 |
| 35 | 95·0 | 28·0 | 12 | 53·6 | 9·6 | − 11 | 12·2 | − 8·8 | − 34 | − 29·2 | − 27·2 |
| 34 | 93·2 | 27·2 | 11 | 51·8 | 8·8 | − 12 | 10·4 | − 9·6 | − 35 | − 31·0 | − 28·0 |
| 33 | 91·4 | 26·4 | 10 | 50·0 | 8·0 | − 13 | 8·6 | − 10·4 | − 36 | − 32·8 | − 28·8 |
| 32 | 89.6 | 25·6 | 9 | 48·2 | 7·2 | − 14 | 6·8 | − 11·2 | − 37 | − 34·6 | − 29·6 |
| 31 | 87·8 | 24·8 | 8 | 46·4 | 6·4 | − 15 | 5·0 | − 12·0 | − 38 | − 36·4 | − 30·4 |
| 30 | 86·0 | 24·0 | 7 | 44·6 | 5·6 | − 16 | 3·2 | − 12·8 | − 39 | − 38·2 | − 31·2 |
| 29 | 84·2 | 23·2 | 6 | 42·8 | 4·8 | − 17 | 1·4 | − 13·6 | − 40 | − 40·0 | − 32·0 |
| 28 | 82·4 | 22·4 | 5 | 41·0 | 4·0 | − 18 | − 0·4 | − 14·4 | − 41 | − 41·8 | − 32·8 |

*Comparison of the Scales for each Tenth of a Degree.*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cent. . | 0·1 | 0·2 | 0·3 | 0·4 | 0·5 | 0·6 | 0·7 | 0·8 | 0·9 | 1·0 |
| Fahr. . | 0·18 | 0·36 | 0·54 | 0·72 | 0·9 | 1·08 | 1·26 | 1·44 | 1·62 | 1·8 |
| Reau. . | 0·08 | 0·16 | 0·24 | 0·32 | 0·4 | 0·48 | 0·56 | 0·64 | 0·72 | 0·8 |
| Fahr. . | 0·1 | 0·2 | 0·3 | 0·4 | 0·5 | 0·6 | 0·7 | 0·8 | 0·9 | 1·0 |
| Cent. . | 0·06 | 0·11 | 0·17 | 0·22 | 0·28 | 0·33 | 0·39 | 0·44 | 0·5 | 0·56 |
| Reau. . | 0·04 | 0·09 | 0·13 | 0·18 | 0·22 | 0·27 | 0·31 | 0·36 | 0·4 | 0·44 |
| Reau. . | 0·1 | 0·2 | 0·3 | 0·4 | 0·5 | 0·6 | 0·7 | 0·8 | 0·9 | 1·0 |
| Fahr. . | 0·22 | 0·45 | 0·67 | 0·9 | 1·12 | 1·35 | 1·57 | 1·80 | 2·02 | 2·25 |
| Cent. . | 0·12 | 0·25 | 0·37 | 0·5 | 0·62 | 0·75 | 0·87 | 1·00 | 1·12 | 1·25 |

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# PART I

## ERRATA

Page 112, line 7, *for* Geant *read* Géant.
Page 139, line 20, ,, ,,
Page 140, line 19, ,, ,,
Page 148, line 11, *for* chamsin *read* khamsin.
Page 193, line 7, *for* khamseen *read* khamsin.
Page 372, line 23, *for* Bourbonnelles Bains *read* Bourbonne-les-Bains.

## ERRATUM

Page 216, Reference 2, *for* F. M. Sandworth *read* F. M. Sandwith

## Comparison of the Centrigade Thermometer with Fahrenheit's and Reaumur's, giving the Corresponding Values for each Degree, from +50° to −41° Centrigade.

From A. Buchan's *Introductory Text-Book of Meteorology.*

| Cent. | Fahr. | Reau. | Cent. | Fahr. | Reau. | Cent. | Fahr. | Reau. | Cent. | Fahr. | Reau. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| 50 | 122·0 | 40·0 | 27 | 80·6 | 21·6 | 4 | 39·2 | 3·2 | −19 | − 2·2 | −15·2 |
| 49 | 120·2 | 39·2 | 26 | 78·8 | 20·8 | 3 | 37·4 | 2·4 | −20 | − 4·0 | −16·0 |
| 48 | 118·4 | 38·4 | 25 | 77·0 | 20·0 | 2 | 35·6 | 1·6 | −21 | − 5·8 | −16·8 |
| 47 | 116·6 | 37·6 | 24 | 75·2 | 19·2 | 1 | 33·8 | 0·8 | −22 | − 7·6 | −17·6 |
| 46 | 114·8 | 36·8 | 23 | 73·4 | 18·4 | 0 | 32·0 | 0·0 | −23 | − 9·4 | −18·4 |
| 45 | 113·0 | 36·0 | 22 | 71·6 | 17·6 | − 1 | 30·2 | − 0·8 | −24 | −11·2 | −19·2 |
| 44 | 111·2 | 35·2 | 21 | 69·8 | 16·8 | − 2 | 28·4 | − 1·6 | −25 | −13·0 | −20·0 |
| 43 | 109·4 | 34·4 | 20 | 68·0 | 16·0 | − 3 | 26·6 | − 2·4 | −26 | −14·8 | −20·8 |
| 42 | 107·6 | 33·6 | 19 | 66·2 | 15·2 | − 4 | 24·8 | − 3·2 | −27 | −16·6 | −21·6 |
| 41 | 105·8 | 32·8 | 18 | 64·4 | 14·4 | − 5 | 23·0 | − 4·0 | −28 | −18·4 | −22·4 |
| 40 | 104·0 | 32·0 | 17 | 62·6 | 13·6 | − 6 | 21·2 | − 4·8 | −29 | −20·2 | −23·2 |
| 39 | 102·2 | 31·2 | 16 | 60·8 | 12·8 | − 7 | 19·4 | − 5·6 | −30 | −22·0 | −24·0 |
| | | | | | | [illegible] | [illegible] | [illegible] | −31 | −23·8 | −24·8 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cent. | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Reau | 0·04 | 0·09 | 0·13 | 0·18 | 0·22 | 0·27 | 0·31 | 0·36 | [illegible] | [illegible] |

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# PART I

## METEOROLOGY

# CHAPTER I

## THE ATMOSPHERE

THE atmosphere may be regarded as a great ocean encircling the earth to a height of probably about 200 miles. Little more than one hundred years have elapsed since its real nature was discovered. In 1774 Priestley found out that it was composed of at least two gases, oxygen and nitrogen; and in 1789 Lavoisier showed that it consisted of one part of oxygen and four parts of nitrogen. We need not stop to consider how this brilliant discovery was made, and how it became the foundation of modern chemistry. Let it suffice to say that Lavoisier's results were confirmed, and were added to by succeeding observers. In 1894 Lord Rayleigh and Professor Ramsay showed that another gas, which they named argon, is present to the extent of about 1 per cent. Subsequently Ramsay and Travers announced the discovery of other atmospheric elements—neon, krypton, and xenon.

Since the days of Lavoisier numerous analyses of the air have been made. Specimens from the Polar Regions and from the Equator, from deep valleys and from lofty mountains, have been submitted to examination. The outcome of these researches is not a little remarkable. The average composition of the air is everywhere the same: the same constituents are present, and in the same proportion, apart from occasional small accidental variations. The essential components of perfectly dry air—air entirely free from vapour of water—are oxygen, nitrogen, and argon, with a

minute proportion of carbonic acid. The mean result of many analyses, according to Leduc, is expressed by the following figures:[1]—

| | Oxygen. | Nitrogen. | Argon. | Carbonic Acid. |
|---|---|---|---|---|
| Per cent by weight . | 23·19 | 75·46 | 1·30 | 0·05 |
| Per cent by volume . | 20·99 | 78·04 | 0·94 | 0·03 |

These are the essential constituents; but others in variable amount are always present. Of these, the most important is the vapour of water. Ammonia also is always present in greater or less degree. Minute quantities of ozone and of peroxide of hydrogen are sometimes present. In addition to the ordinary constituents, certain impurities are more or less frequent. Nitric and nitrous acids, sulphuric and sulphurous acids, and many other gases, are found in the air of manufacturing towns, often destroying the vegetation for miles around.

Besides the gaseous impurities innumerable minute solid particles float in the air. By a beam of sunlight in a darkened room myriads of them can be seen, though others smaller still, including micro-organisms, can be detected only by other means.

The essential constituents of the air, it has just been remarked, always bear nearly the same proportion to each other: the variations that occur are slight. Yet every living creature on the surface of the globe is constantly using up the oxygen and giving out carbonic acid, and to such an extent that a healthy man of 75 kilos at rest would in the course of twenty-four hours use up 523 litres of oxygen and give out 450 litres of $CO_2$. Every fire, every flame of lamp, candle, or gas in like manner removes oxygen and pours out carbonic acid. Were the oxygen in the atmosphere not renewed, the entire stock would gradually diminish and would one day fall short. The proportions, however, do

not change. The oxygen is not wasting away, and there are no threatenings that the air will be turned into a lethal gas by the accumulation of carbonic acid.

In what way is the oxygen restored to the atmosphere, and how is the carbonic acid removed? What is the mechanism by which renewal as well as destruction takes place?

The process is one of the simplest and most beautiful instances of mutual compensation, of harmonious interchange of force, presented throughout the entire domain of nature.

"The breath of life" is no mere figure of speech. All organised bodies—vegetable as well as animal—must breathe in order to live. The used-up air of one half of creation is the fresh air of the other. Animals take oxygen from the air and replace it by carbonic acid. Plants take up carbonic acid and give out oxygen in return. Thus on a grand scale an interchange of respired gases takes place between the two great divisions of organic nature.

Oxygen and carbonic acid are only two of the components of air. Nitrogen is not used up in respiration. So far as man is concerned, its function in the atmosphere is only to dilute the oxygen. Does it then remain unaltered? No; like its companion gases, it is subject to constant destruction and renewal. In its period of chemical circulation it enters into many combinations before returning to its original free state. It is an essential constituent of the vegetable and, to a very much greater degree, of the animal kingdom. From the air it is absorbed by growing plants; and these in turn deliver it up as food for animals. Animal and vegetable alike in decaying are resolved more or less into their simpler constituents. Without following nitrogen in its cycle of changes we may say that it is absorbed by trees and plants during their period of growth, and is yielded up again directly or indirectly from animal and vegetable matter in decay.

This sketch leaves one important point unexplained.

Over the tops of mountains and immediately above the surface of the earth the composition of the air is practically identical. The air on the summit of Pichincha (15,960 feet high, close to Quito), the air of the South Sea, and the air over the Arctic Ocean have given, as the result of many examinations, proportions differing from each other only by minute fractions. What is the explanation?

It might be expected that oxygen would accumulate near forests, and that carbonic acid would accumulate in the neighbourhood of towns. In days gone by, men spoke of the strongly oxygenated air of mountains and of the carbonated air of the valleys and plains. In fact, the difference is almost inappreciable; but what difference there is, is often exactly the opposite of that suggested by preconceived ideas. According to de Saussure, carbonic acid is by a minute fraction more abundant in the mountains than in the plains. More recent observations, however, throw doubt on this view.

By what means is this uniformity of composition maintained? Two agencies are at work: winds and the laws regulating the diffusion of gases. When we come to consider the winds, we shall see how powerful is their influence, and with what orderly movement the atmospheric ocean circulates over the face of the earth. Illustrations of diffusion will be mentioned presently.

Although the composition of the air on the average is everywhere the same, certain slight variations in the same place occur.

The amount of oxygen is sometimes greater, sometimes less than the average at the same place at different times. Macagno in Palermo, for example, found that the proportion of oxygen varied from 20·92 per cent to 20·717 per cent; and on one occasion, when the scirocco was blowing, it amounted to only 19·994 per cent. Jolly at Munich obtained somewhat similar results, the range in his analysis being almost 0·5 per cent (21·01 per cent to 20·53 per cent = 0·48 per cent).[2]

The circumstances that determine these variations in the

essential components of the air must be looked at for a moment. The amount of oxygen formed depends on vegetation and on light. Only under the influence of light do plants absorb carbonic acid and give out oxygen.

The amount of carbonic acid, according to the researches of de Saussure, depends upon the following conditions: first, light, the gas being less on bright days; secondly, moisture of the soil, which diminishes the amount of carbonic acid in the air; thirdly, height of the air from the ground, the quantity increasing with the height, to a certain distance at least. The explanation of these influences is easy. Light acts through the vegetable world by causing the absorption of the carbon by plants. Moisture has great capacity for absorbing carbonic acid, and hence the gas in contact with moist soil disappears. For the same reason soil in drying gives out carbonic acid. The increase of the carbonic acid with height might be accounted for by the increased distance from the agents that remove it. More recent observations, however, tend to show that $CO_2$ diminishes slightly in amount as we ascend.

In manufacturing cities, where carbonic acid is produced in enormous quantities, it might be expected to form a much greater proportion of the air than elsewhere. For example, in Manchester, according to Angus Smith's calculation, nearly eight (7·78) million cubic metres of carbonic acid are produced daily; and yet the streets there contain only four volumes per ten thousand.[3] The explanation of this lies in the fact that gases undergo diffusion with extreme rapidity. Another example illustrating the same point may be given. In examining the air over the Marienquelle in Marienbad, Pettenkofer found that at 5 centimetres over the surface of the water it contained 31 per cent of carbonic acid, at 25 centimetres 23 per cent, at 1 metre 2 per cent, and at 145 centimetres only 0·5 per cent.

Ammonia is also found as a constant constituent of the air. It arises through the disintegration of organic sub-

stances. The amount present varies within wide limits: from an average of 0·02 milligramme per cubic metre (less than $\frac{1}{100,000}$ of a grain per cubic foot) in Montsouris near Paris, to 62·3 milligrammes per cubic metre (less than $\frac{1}{35}$ of a grain per cubic foot) in Boston in July.[4] These very great differences, not corresponding to the laws of diffusion of gases, indicate that ammonia exists in the air in solid form, probably as carbonate or as nitrate or nitrite, either in soot particles or other kinds of dust. An additional fact pointing in the same direction is that with continuous rain the quantity of ammonia in the rain water steadily diminishes on each succeeding day.

Two other gaseous constituents, ozone and peroxide of hydrogen, have already been mentioned. Ozone is a modification of oxygen in which three atoms combine to form one molecule; in peroxide of hydrogen two atoms of oxygen are combined with two atoms of hydrogen. Ozone, which was discovered by Schönbein, can be produced artificially by making an electric discharge through oxygen. In this process the gas is reduced to two-thirds of its previous volume, acquiring at the same time many new properties. It becomes then an oxidising agent of great power.

The ordinary test for ozone is based on its property of freeing iodine from a solution of iodide of potassium in contact with starch, a violet colour being thus developed. Many observations have been made on its presence and amount in various places and under various circumstances. These observations, however, must now be regarded as almost worthless. The test is open to four sources of error. First, other substances in the air act as reducing agents: nitrous acid, for example, which arises from explosions of gunpowder. Secondly, the colour after having appeared may be discharged by certain other substances, such as sulphurous acid and many organic substances. Thirdly, the test acts only in a moist atmosphere, and so would serve rather as a test of moisture than of ozone. Fourthly, the amount of ozone brought into contact with the test paper

is great in proportion to the amount of wind; and so the test is more nearly a measure of wind than of ozone. Another test has been put forward as more sensitive than the iodine one. This is what is known as tetra-paper, or more exactly as tetramethylparaphenylendiamin paper. It also yields only uncertain results. We have at present no trustworthy method of estimating the quantity of ozone in the air. We know, however, that it is formed during electric discharges; and the peculiar smell often noticed after a thunderstorm, like that produced by a static electric machine, is due to the ozone in the air. When the sources of error just mentioned have been as far as possible excluded and due allowance has been made for their possible presence, the conclusion remains almost certain that ozone is much more abundant by the seashore, in mountain districts, and in the country than in towns, where in fact it can hardly be detected. It is also most abundant in May and in June: least abundant in December and January. The average amount has been estimated as about 1 to 2 milligrammes and the maximum 3·5 milligrammes in 100 cubic metres of air.

Peroxide of hydrogen is also occasionally present. It is formed during the evaporation of water exposed to sunlight, and has probably been taken for ozone, as, owing to its oxidising power, it answers to the same tests. Whether any important influence can be ascribed to the minute quantities that are found in the air is doubtful.

Of impurities in the air there are a great many, including compounds of carbon, of sulphur, of chlorine, of nitrogen, of phosphorus. Some of these are organic vapours arising from decomposing animal and vegetable matters. These impurities are important as regards ventilation, but have little or no bearing on climate. They will therefore not be further referred to.

The solid impurities require a somewhat more extended notice.

Besides gaseous impurities innumerable solid particles invisible to the eye float in the air. A beam of sunlight

passing through a dark room reveals myriads of minute objects floating about. These solid particles when separated from the air and examined are found to consist partly of mineral and partly of organic matter, in which several varieties of living organisms have been distinguished. Amongst the most important organic constituents of dust are the following: Various kinds of micrococci and bacteria, spores of fungi, parts of flowers, especially pollen, cuticular scales, and seed capsules, minute portions of animals, such as scales, wings, and legs of insects. Besides these there are minute particles of wood and fibres of various kinds. The inorganic substances consist of chalk, clay, sand, and often in the neighbourhood of towns fine particles of metals. In the dust of the streets of Dublin Mr. Tichborne found organic matter present in proportions varying from 29·7 per cent to 45·2 per cent. The organic matter of dust in Paris, according to Tissandier, ranges from 25 to 34 per cent.[5] As might be expected, the air of cities contains a very much greater amount of dust than does the air of the country; but nowhere is the air entirely free from it. Ehrenberg examined dust from the air of Berlin, Petersburg, Tobolsk, Zürich, Venezuela, Lebanon, the highest peaks of the Himalayas, as well as the dust from country roads, sitting-rooms, barracks, and hospitals, and everywhere he found a great number of the lower forms of animal and vegetable life. In 1871 he examined dust carried by a trade wind, and was able to distinguish 460 different kinds of organic forms.[6]

After rain there is a very great diminution of dust in the air. In Paris, Tissandier found after a prolonged period of dry weather 23 milligrammes of dust in each cubic metre of air, and after rain only 6 milligrammes per cubic metre. In the country after a spell of dry weather from 3 to 4·5 milligrammes of dust per cubic metre were found, and after rain the quantity was only 0·25 milligrammes.[7]

Fodor found that in Buda Pesth the air contained less dust in spring and winter than in summer and autumn, the

smallest quantity corresponding with the greatest amount of rain. Living organisms are especially infrequent in winter. Cunningham, however, found in India that after showers or rainy days the inorganic constituents of dust in the air were greatly diminished, but that there was no diminution but rather an increase of the organisms present.[8]

Aitken by means of his "dust counter" has shown much greater quantities of dust in the air than had previously been suspected. He found dust particles averaging from 340 per cubic centimetre in air over the Atlantic and 550 in the air of the Highlands of Scotland to 170,000-470,000 in Glasgow in winter.[9]

Micro-organisms are always more or less present in the atmosphere. They vary in number from perhaps 100 to 1000 per cubic metre. Five-sixths of these on an average are fungi, and only about one-sixth bacteria. Of these latter, few are pathogenic; and bacteria, unlike fungi, do not live long in the air.

For a long time it was taken for granted that with the evaporation of water from moist earth or decomposing matter minute organisms pass into the atmosphere. The most careful researches, however, failed to establish this view; and it is now almost certain that such organisms find their way into the air only when they are thrown directly into it by wind or by the spray of water, as in a waterfall or in breaking waves.

Common salt, or chloride of sodium, is also always present in the air. It is derived from the ocean. Spray is carried up into the air, and the water being converted into vapour, the salt in extremely minute particles floats about as dust.

Dust from volcanoes as a constituent of the air is found only now and then and for comparatively short periods.

Dust from meteorites is only an occasional constituent, and is made up chiefly of nickel.

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3. Renk, *op. cit.* p. 30.
4. Renk, *op. cit.* p. 40.
5. Renk, *op. cit.* p. 126.
6. Renk, *op. cit.* p. 128.
7. Renk, *op. cit.* p. 124.
8. Renk, *op. cit.* p. 131.
9. Hann, *op. cit.* p. 16.

# CHAPTER II

## TEMPERATURE

FOR many years careful observations respecting temperature have been made all over the world; and charts have been constructed showing the results. On these charts, places having the same temperature are connected by what are termed isothermal lines. These lines present a general resemblance to the parallels of latitude, but only a general resemblance, for unlike the parallels of latitude they show many curves, and the curves vary at different times of the year.

The first thing we learn from examination of such charts is that the temperature decreases from the Equator to the Poles, and next that the rate of decrease is different over oceans and over continents. In summer the decrease from Equator to Pole is more marked over the ocean, and in winter it is more marked over the continent. The explanation of these facts will be seen presently.

The temperature of a place depends (1) on the amount of heat it receives, and (2) on the amount of heat it is able to store up.

The amount of heat received depends on various circumstances. A surface placed perpendicularly to the rays of the sun receives a greater number of rays than if placed slantingly to them. This is the chief reason why the Tropics are warmer than the Poles. The length of time the sun is over the horizon is hardly less important. The longer the sun shines on a place the warmer the place becomes. The greater heat of summer is due to these two circum-

stances: the more vertical direction of the sun's rays and the longer exposure to them. Another circumstance that determines the amount of heat received is the humidity of the atmosphere. Dry air allows the heat rays of the sun to pass through. Moisture in the air, on the contrary, absorbs them. Places near the sea, therefore, where the air is moist, receive somewhat less heat than places inland, but store it up better.

The prevailing winds also greatly modify temperature, having a warming or cooling influence as they come from a warm or from a cold region. Owing to the warm, moist winds coming from the Gulf Stream, the temperature, for example, is several degrees warmer in winter in the British Isles than in other places in the same latitude.

The amount of heat stored up depends upon various circumstances. Chief amongst these is the moisture of the air, and this again depends partly on the supply of water, and partly on the temperature. Other important influences at work are the character of the soil, the vegetation, and the configuration of the district.

That water should be the means of trapping and storing up the heat of the sun is not by any means evident at the first glance. Our familiar experience of mist, rain, and snow does not prepare us to regard the water in the air as the great storehouse of heat on the earth. How do we know that a process seemingly so much in contradiction with everyday observation is actually at work? The evidence comes from various quarters.

Experiments have shown that when heat is applied to water one of two things happens: the water either becomes warmer, or undergoes a change of form without change of temperature. Every one knows how it becomes warmer, and on that point nothing more need be said. The other result is seen in two different conditions: when heat is applied to ice, and when water is converted into vapour. When a dish of ice is exposed to heat, the heat seems to disappear mysteriously, and until the last particle of ice is melted, the contents of the dish hardly rise above the

freezing-point. If the water be again turned into ice, the heat that had mysteriously disappeared is again liberated. During the melting of the ice it had been absorbed: it ceased to be recognisable by the senses, it had become latent. When the water is again turned into ice all this heat is given out: it again becomes sensible. In changing water from the fluid into the gaseous state, heat undergoes a similar transformation from the sensible to the latent condition.

As clear ideas on this point are important, we will go a little more into detail. In two ways water is converted from the fluid form into vapour: by boiling and by evaporation. The temperature at which water boils depends upon the pressure of the air. At the ordinary pressure of 760 mm. (30 in.) it boils at 100° C. (212° F.). At half that pressure, 380 mm., it boils at 82° C. (180° F.); while at 4·6 mm. pressure it boils at 0° C. (32° F.).

Evaporation is always taking place from the surface of water freely exposed to the air. The rate of evaporation depends upon the pressure of the atmosphere and upon the temperature; the less the pressure and the higher the temperature the more rapid is the evaporation. In order to convert a given quantity of water into vapour a certain definite amount of heat is required. If we adopt the metric form of expression, a unit of heat is the amount required to raise one kilogramme of water one degree Centigrade. Now to convert one kilogramme of water at 0° C. into vapour at the same temperature, 607 units of heat are required. The heat seems to disappear mysteriously. In reality it becomes latent. The change in the form of water from the liquid to the gaseous state requires the expenditure of energy. This work is done by the transformation of heat. The energy previously recognisable as sensible heat is now occupied in keeping the molecules of water in a state of repulsion. To convert a kilogramme of water at 100° C. into vapour only 537 units are necessary. Thus the latent heat of aqueous vapour diminishes with the rise of temperature. With the return of vapour to its liquid form, heat is given out; and an easy calculation shows that every

pound of water that is condensed from vapour liberates heat enough to raise the temperature of more than 58 lbs. of lead to its melting-point, or to heat and melt more than 38 lbs. of lead or 5 lbs. of cast-iron.*

The moisture in the air, then, is the great store-house of heat. Let us now see in what way the moisture acts.

Evaporation is constantly going on from the surface of water in the open air. When the surface of the earth gets heated, evaporation takes place in due proportion, provided the supply of water is at hand. The heat is partly expended, not in warming the air, but in converting water into vapour. If, on the contrary, there is no supply of water at hand, the vapour already in the air becomes still further warmed; and under such circumstances also it parts readily with the heat it has acquired.

In another way the invisible water vapour in the air keeps heat from escaping from the earth. It hinders radiation, it does not allow heat readily to pass through, being only semi-permeable to heat rays. When the air contains little moisture, radiation is great, dry air being diathermanous. Much moisture, when present, acts as a cloak, arresting the passage outwards of the warmth. Thus in all dry climates the daily changes of temperature are great. During the day the air becomes overheated, while at night by radiation the heat is quickly lost.

So far we have looked only at the two chief agencies in determining temperature, namely, latitude and humidity. A third, hardly less important, remains to be examined, namely, altitude. As we ascend from the surface of the earth the air gets colder. Why is this? It is mainly due to the physical laws of the expansion of gases. Let us look into the point a little more closely.

* If the latent heat of evaporation of water at 10° C. is 600 Calories, the latent heat of fusion of lead = 5·37 Calories, the specific heat of lead = 0·0314, and its melting-point 326° C.

Then 0·0314 Calories raise by 1° C. the temperature of 1 lb. of lead,
and 600 ,, ,, 326° C. ,, ,, 58·6 lbs. ,,
Likewise 392·7 Calories raise by 326° C. the temperature of 38·5 lbs., and (38·5 × 5·37 =) 206·7 Calories change 38·5 lbs. of lead into fluid state. It needs, therefore, 392·7 + 206·7 = 599·4 Calories to heat and melt 38·5 lbs. of lead.

As the volume of a gas increases, its temperature falls. The heat is converted into the energy of motion. In other words, the energy previously recognised as heat is now occupied in keeping the particles of gas in a state of greater repulsion. Let us apply these principles to the atmosphere. When air on the surface of the ground is heated it expands and reaches a higher level; but when it reaches that higher level it comes under diminished pressure. The superincumbent column of air is less. There is now, therefore, an additional expansion from this cause. The heat is now used, as just said, in keeping the molecules of air farther apart from each other, the temperature consequently sinking. If the air from its lowest to its highest level were homogeneous throughout, the rate of fall of temperature in accordance with this law would be 1° F. for every 180 feet of ascent, or 1° C. for every 100 metres, always provided that the diminution of temperature did not anywhere give rise to condensation of water-vapour.

But when observations are made in a mountain ascent or in a balloon, the facts do not correspond exactly with what this simple theory would require. The rate of diminution is really much slower, as a rule, and sometimes not a diminution but an increase of heat is found. The average rate of diminution of temperature with height is 0·56° C. for each 100 metres, or 1° C. for 180 metres. This roughly corresponds with 1° F. for each 300 feet of ascent. The rate, however, is not so uniform as to warrant precise expression. In the upper strata of air the diminution goes on rapidly; but in the lower strata the rate is subject to great modification according to the amount of water-vapour in the air, the clearness of the atmosphere, the heating of the ground, and the amount of wind. The atmosphere is warmed mainly, not by intercepting heat from the sun, but by contact with the earth. The heat from the sun passes freely through dry air, but is diminished or kept back by the water-vapour present. The air in contact with ground heated by the sun expands on becoming warm, and consequently ascends. Colder air comes to replace the ascending

current, and the air becomes warmed to a gradually increasing height. To this process is added the influence of radiation, and the influence of water-vapour condensing into visible moisture in the form of cloud or even of haze.

All these causes combine to prevent the temperature of the air from diminishing with height at the rate that would be caused by expansion alone. Sometimes, however, when the ground is greatly heated by a powerful sun, the heating of the air near the earth is so great that the fall of temperature with height would be more rapid than what would be required by theory.

At night the temperature is commonly lower immediately over the ground than at a somewhat greater height, and for a varying elevation above ground the temperature continues to rise.

This inversion of the temperature at night was for a long time considered an anomaly, but is now known to be the normal condition. When the sun goes down the ground becomes cold by radiation. In the absence of wind the air, cooled by contact with the ground, remains the lowest layer. The air does not radiate its heat as rapidly as does the earth, and consequently the warmed layers lose their heat more slowly than does the ground. The cooling of these layers is retarded by the heat radiated from the ground, and sometimes also by the condensation of vapour.

This inversion of the temperature at night is most marked in high mountain valleys, where indeed it occurs by day as well as by night, the ground, being covered by snow, no longer getting heated by the sun during the day.

These are the most general facts concerning the change of temperature with altitude. Some special features are reserved for consideration till we deal with the influence of mountains on climate.

Another factor of great influence in modifying temperature is vegetation. As a general rule vegetation lessens the extremes both of heat and of cold. This it does chiefly by means of the moisture which it throws into the air.

A prevalent wind also modifies temperature considerably.

The influence of winds from the Gulf Stream on the climate of the British Islands need only be mentioned here. Later the subject will be examined more in detail.

The main conditions on which temperature depends have now been passed in review. A few general facts touching the distribution and the range of temperature remain for consideration.

The distribution of temperature over the surface of the earth must now be looked at. To the meteorologist this is of prime importance, but to the physician of only subordinate interest. The physician requires to know, not how the temperature is distributed on the average, but the minute characteristics of temperature at different places We shall therefore deal only slightly with the meteorological portion of the subject, reserving the details for consideration till we speak about individual health resorts.

The usual way to give information about the temperature of a place is by stating the mean annual temperature of the seasons. In illustration of this I give a table from Woeikof[1] setting forth the mean temperature of various latitudes :—

DECREASE OF TEMPERATURE FROM THE EQUATOR TO THE NORTH POLE.

| North Latitude. | Mean Temperature. | | | Difference between coldest and warmest Month. |
|---|---|---|---|---|
| | Year. | January. | July. | |
| Degrees. | ° C. | ° C. | ° C. | ° C. |
| 0 | 25·9 | 26·2 | 25·4 | 0·8 |
| 10 | 26·4 | 25·7 | 26·7 | 1·0 |
| 20 | 25·6 | 21·7 | 28·1 | 6·4 |
| 30 | 20·3 | 13·9 | 27·3 | 13·4 |
| 40 | 14·0 | 3·9 | 23·8 | 19·9 |
| 50 | 5·6 | −7·2 | 18·1 | 25·3 |
| 60 | −0·8 | −16·0 | 14·1 | 30·1 |
| 70 | −19·9 | −25·5 | 7·2 | 32·7 |
| 80 | −16·5 | −32·0 | 2·6 | 34·6 |
| 90 | −20·0 | −36·0 | 2·0 | 38·0 |

From this table it will be seen that while the temperature diminishes from the Equator to the Pole the difference between the warmest and the coldest month is slight in the Tropics and great in the Arctic regions. It might be erroneously inferred that the mean temperature fairly represents the temperature usually found at a place. Nothing, however, could be farther from the truth. The mean temperature, resulting from observations during the coldest as well as during the warmest time of the day, may hardly ever be observed. Where the range of temperature is great, where the cold before sunrise is intense and the heat during the period of sunshine is great, the result is a medium temperature, which on any individual day would be found only twice for a few minutes in the twenty-four hours. To take an example, Brighton and Odessa have practically the same mean annual temperature, but the average temperature of January is 14° F. higher and of July 12° F. lower in Brighton than in Odessa, the range (between the coldest and the warmest month) being in Brighton 21° F. and in Odessa 47° F. A still more instructive example is the case of Quito. This town is situated on the Equator at a height of 2850 metres (9350 feet) above sea-level. The climate of Quito is often spoken of as being one of perpetual spring, and it is called equable, the mean temperature for the year being 55·6° F., the coldest month 54·5° F., and the warmest month 56·5° F. The difference, therefore, between the coldest and the warmest month is only 2° F. But the daily range of temperature at some periods of the year is not less than 34° F. Jourdanet,[2] who lived for many years in Mexico, gives a vivid description of the intense heat by day and the fearful cold by night experienced in a fertile valley called Saint-Martin Tesmelucan. It was not an infrequent occurrence for crops quickly brought to maturity under the scorching heat of a tropical sun, rendered hotter by the absence of water-vapour in the air, to be utterly destroyed by frost at night; and yet the hottest and coldest months of this place differ in temperature only by a few degrees.

Wind has been mentioned as one of the chief subordinate influences in determining temperature. The north-eastern coasts of continents in the Northern Hemisphere receive wind from the Arctic regions, and have for this reason a very much lower temperature than the north-western coasts.

## REFERENCES

1. Woeikof, *Die Klimate der Erde*, 1887, Ersler Theil, S. 331.
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## CHAPTER III

### HUMIDITY

Humidity is one of the most important factors of climate. We have already seen how the moisture in the air acts as a storehouse of heat. The laws that regulate the presence of water-vapour itself must now be considered.

By humidity of the air is meant the invisible water-vapour present. This definition excludes clouds, fogs, rain, hail, and snow.

The vapour of water is a gas, and behaves like other bodies of the same kind in regard to expansion, diffusion, and other physical laws. It has, however, one remarkable peculiarity which distinguishes it from most gases, and to which its great climatic influence is due. It assumes a liquid form at a comparatively high temperature and comparatively low pressure. In undergoing this change it has, as we have already seen, the further remarkable property of giving out an enormous quantity of latent heat, its capacity in this respect being greater than that of any other known substance.

We will glance quickly at the physical properties of water-vapour considered as gas. It has little more than half the weight of air, its specific gravity being 0·623, air being taken as unity. The amount that can remain in the form of vapour in a given space depends entirely on the temperature. Air has no influence upon the amount. A cubic metre of space at a given pressure and temperature can contain a certain definite amount of water and no more. As soon as the temperature is lowered, some of the vapour

is condensed into water, and, on the contrary, when the temperature is raised, the capacity for vapour is increased.

The amount of vapour present in the air is expressed in two different ways. It is spoken of as relative humidity and as absolute humidity. Relative humidity means the amount present as compared with the amount the air could hold at the temperature of the moment; in other words, it is the proportion of actual humidity to the possible amount. Absolute humidity means the amount estimated either by weight per cubic foot or per cubic metre, or by its tension expressed in the number of millimetres of mercury it will support.

Relative humidity is always expressed as a percentage of what the air could hold. Suppose that the air is not saturated with moisture, and that it is then gradually cooled. A point is soon reached when any further cooling gives rise to condensation of the vapour as water. This is termed the dew point; and the air is then said to be saturated with moisture, and its relative humidity is said to be 100. Now, the dew point being known, and the amount of water capable of existing as vapour at a given temperature in a given space being known, the absolute amount of moisture present can easily be calculated. This is expressed either as grammes per cubic metre or as grains per cubic foot, or, what is more usual, as the tension represented by the height of a column of mercury that it will support, and tables for this purpose are given in meteorological works. As a matter of fact, it happens that each milligramme of the mercurial column nearly corresponds to 1 gramme of water-vapour per cubic metre. Thus, if we say that the vapour tension is 12 milligrammes, we may practically regard it as equivalent to 12 grammes of water-vapour in a cubic metre of air.

I give here a table[1] showing the tension of aqueous vapour at various temperature:—

[TABLE

TENSION OF AQUEOUS VAPOUR.

| Temperature. | Tension in mm. | Temperature. | Tension in mm. | Temperature. | Tension in mm. | Temperature. | Tension in mm. |
|---|---|---|---|---|---|---|---|
| °C. | | °C. | | °C. | | °C. | |
| – 10 | 2·078 | 12 | 10·457 | 29 | 29·782 | 90 | 525·45 |
| – 8 | 2·456 | 13 | 11·062 | 30 | 31·548 | 91 | 545·78 |
| – 6 | 2·890 | 14 | 11·906 | 31 | 33·405 | 92 | 566·76 |
| – 4 | 3·387 | 15 | 12 699 | 32 | 35·359 | 93 | 588·41 |
| – 2 | 3·955 | 16 | 13·635 | 33 | 37·410 | 94 | 610·74 |
| 0 | 4·600 | 17 | 14·421 | 34 | 39·565 | 95 | 633·78 |
| 1 | 4·940 | 18 | 15·357 | 35 | 41·827 | 96 | 657·54 |
| 2 | 5·302 | 19 | 16·346 | 40 | 54·906 | 97 | 682·03 |
| 3 | 5·687 | 20 | 17·391 | 45 | 71·391 | 98 | 707·26 |
| 4 | 6·097 | 21 | 18·495 | 50 | 91·982 | 99 | 733·91 |
| 5 | 6·534 | 22 | 19·659 | 55 | 117·479 | 100 | 760·00 |
| 6 | 6·998 | 23 | 20·888 | 60 | 148·791 | | |
| 7 | 7·492 | 24 | 22 184 | 65 | 186·945 | | |
| 8 | 8·017 | 25 | 23·550 | 70 | 233·093 | | |
| 9 | 8·574 | 26 | 24·998 | 75 | 288·517 | | |
| 10 | 9·165 | 27 | 26·505 | 80 | 354·643 | | |
| 11 | 9·792 | 28 | 28·101 | 85 | 433·41 | | |

The relative humidity of a place is usually regarded as being of the greatest importance. But the really essential point is, not the amount of moisture, relative or absolute, that is present, but the amount that can still be taken up. This varies enormously with the same degree of relative humidity at different temperatures, as the following table from Renk [2] will show :—

AMOUNT OF VAPOUR THAT CAN STILL BE TAKEN UP AT DIFFERENT TEMPERATURES AND THE SAME RELATIVE HUMIDITY.

| Temperature. | Relative Humidity. | Absolute Humidity. Grammes per cubic metre. | Grammes of Vapour that can still be taken up. |
|---|---|---|---|
| °C. | Per cent. | | |
| – 20 | 60 | 0·638 | 0·426 |
| – 10 | 60 | 1·380 | 0·920 |
| 0 | 60 | 2·924 | 1·950 |
| 10 | 60 | 5 623 | 3·749 |
| 20 | 60 | 10·298 | 6·866 |
| 30 | 60 | 18·083 | 12·056 |

The following table is the obverse of the preceding one, and shows the various temperatures and relative humidity at which a given amount of water-vapour can be taken up:—

| Temperature. | Relative Humidity. | Vapour. Grammes per cubic metre. | |
|---|---|---|---|
| | | Present. | Capable of being taken up. |
| ° C. | Per cent. | | |
| 3 | 0 | 0 | 6 |
| 10 | 36 | 3·4 | 6 |
| 15 | 53 | 6·8 | 6 |
| 20 | 65 | 11·2 | 6 |
| 25 | 73 | 16·9 | 6 |
| 30 | 80 | 24·1 | 6 |

It is seen, for instance, that the drying power of the air is the same at 30° C. and 80 per cent relative humidity as at 10° C. and only 36 per cent relative humidity.

The amount of moisture present in the air is least during the coldest time of day, that is, just before sunrise; and with certain exceptions is greatest during the hottest time of the day, that is, a little after mid-day. When air is cooled below saturation point, vapour is condensed into water, and the absolute quantity of moisture present is diminished. Thus, in winter, as compared with summer, the amount of moisture is relatively greater but absolutely less.

The humidity of the air diminishes as we ascend. When speaking of temperature, we saw that the air becomes colder by expansion; consequently it can hold less water. Air and water-vapour may be regarded as forming two atmospheres mechanically mixed; and it has been found that the atmosphere of vapour almost disappears before the higher layers of air are reached. The following table from Hann[3] shows the rate of diminution of the two atmospheres, the amount present at sea-level being taken as unity:—

Rate of Diminution of Air and Vapour in Altitudes.

| Height above sea-level. | Water-vapour. | Air. | Height above sea-level. | Water-vapour. | Air. |
|---|---|---|---|---|---|
| Metres. | | | Metres. | | |
| 0 | 1·0 | 1·0 | 5000 | 0·17 | 0·54 |
| 1000 | 0·73 | 0·88 | 6000 | 0·12 | 0·47 |
| 2000 | 0·49 | 0·78 | 7000 | 0·08 | 0·42 |
| 3000 | 0·35 | 0·69 | 8000 | 0·06 | 0·37 |
| 4000 | 0·24 | 0·61 | 9000 | 0·04 | 0·32 |

For example, if the pressure of vapour at sea-level be 10 mm., at 4000 metres it would be only about one-fourth of that amount, or 2·4 mm.; and if the pressure of the air be 750 mm. at sea-level, its pressure at 4000 metres would be 457·5 mm., or nearly two-thirds (0·61) of the original amount. A proportion of about nine-tenths of the aqueous atmosphere lies below a level of 6500 metres.

## Clouds, Fog, Dew, and Rain

All these phenomena are due to almost identical conditions. They are all caused by the cooling of air beyond its saturation point—the different result being due to the circumstances attending the process. Fogs, for example, are simply ground clouds; rain is only a further step in condensation; while dew and hoar frost mean the deposition of moisture, not in the air, but on solid objects. Clouds occur in various ways: by the cooling due to the expansion of ascending air; by the mixture of two masses of air of different temperatures, both nearly saturated with moisture; by the chilling of a warm, moist wind in passing over a cold surface, as, for example, over a cold stream, over a mountain, or over a forest.

The presence of minute particles of dust has been shown to be necessary for the formation of clouds. When dust-free air is cooled beyond the saturation point, condensation of

vapour takes place only on the sides of the vessel in which the experiment is made.

The amount of cloud is one of the most important climatic features of a place, and will be fully dealt with in treating of individual health resorts. The amount of cloud is usually expressed in tenths of the visible heavens. If one-tenth of the sky is covered, the clouding is spoken of as 1; and if half the heaven is covered, it is spoken of as 5. Rainfall is expressed as the height of a column of water formed by the rain over a given area in a given time. Thus a rainfall of one inch would mean that over any given area, if the water were spread evenly all over it, an inch would be its height. Tables showing the annual rainfall in various districts are usually given. These do not, however, afford much information as to the character of the climate. Great quantities of rain may come down in heavy showers during a short time of the day all the year round; or a continuous heavy rain may go on for two or three months, the rest of the year being dry; or, again, rain may fall irregularly and without apparent law. And yet the amount of rain may in each case be the same. Another way of expressing the amount of rain is to give the proportion of rainy days; but from what has been said it will be seen that this plan is really not much better than the one it is intended to replace. In some regions the rain comes on regularly for a short time every day. At Rio Janeiro it is said to have been the fashion to state in invitations for the afternoon whether the guests were to assemble before or after the thunderstorm, which came on regularly at a certain hour.[4] The clouds in such a case would form in the forenoon, rain falling heavily in the afternoon, the sky then clearing for the night. To deal with such a place simply by numbering its rainy days would not represent it properly. Formerly the statement used to be made that rain diminishes in abundance regularly from the Tropics to the Poles; the rainfall in the Torrid Zone being put down at 100 inches, in the Temperate Zone at 30 inches, and in the Frigid Zone at 15 inches. There is a diminution, but it is by no means a regular one, the

rainfall in the interior of the continents in low latitudes being small—as, for example, in the Desert of Sahara—and great on coast lines in high latitudes.

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3. Hann, *Handbuch der Klimatologie*, 2te Auflage, 1897, Bd. I. S. 279.
4. R. H. Scott, *Elementary Meteorology*, 4th edition, 1887, pp. 147, 342.

# CHAPTER IV

## PRESSURE

THE weight of air supported by an ordinary grown-up man is between 12 and 14 tons; yet for thousands of years people walked about on the face of the earth without guessing the burden that rested on them. Galileo suspected that air had weight, but he only suspected it; and he was greatly puzzled as to why the piston of a pump would not draw water to a greater height than about 33 or 34 feet. In 1643 Torricelli made the grand discovery. He looked at the difficulty from another point of view, and asked why the piston should draw water up at all. The idea struck him that the piston acted merely by removing the weight of the air from the water in the pump, the pressure of the air on the water outside forcing up the water within the pump; the water not rising higher than 35 feet, because at that height the column of water was as heavy as the balancing column of air. He proceeded to test his supposition. Mercury is fourteen times heavier than water, and, if his view was correct, the column of mercury would be fourteen times less than the column of water required to balance the air. He got a glass tube about a yard long closed at one end. He then filled it with mercury, and immersed the open end in a dish containing the same metal. What he expected happened. The mercury sank about 6 inches in the tube, standing at a height of about 30 inches. The weight of this column of mercury was therefore the weight of a column of air of the same area. Roughly speaking, a cubic inch of mercury weighs half a pound. Thirty inches,

therefore, would have a pressure of 15 lbs. Consequently at sea-level this would represent the pressure of the atmosphere over every square inch of surface. And when the square inches of surface presented by the full-grown human body are reckoned up it is found that the entire weight amounts to between 12 and 14 tons.

The next great discovery in regard to the pressure of air was made by Pascal, the experiment being carried out by his brother-in-law, Périer.

Pascal said that if the view taught by Torricelli was correct, a smaller column of air would naturally support only a smaller column of mercury. By going up a mountain one could get this smaller column of air. In 1648 Périer, at Pascal's request, made the experiment. He ascended the Puy-de-Dôme in Auvergne, 3500 feet high, and found that the column of mercury was between three and four inches less in height than at Clermont in the plain.

We shall now go a little into detail concerning some of the physical properties of air and the laws which regulate its pressure.

The weight of a cubic metre of air at 0° C. at sea-level is 1·2932 kilos, or about $2\frac{1}{2}$ lbs. The pressure of the air is due to two different elements, its weight and its tension. A subsidiary element is the tension of the water it contains.

Let us make clear the meaning of these different expressions. The air over a certain spot may be considered to form a column, and its weight is the weight of the whole column. So much for the weight. Now what is tension? The particles of air, like the particles of all other gases, are in a state of repulsion to each other. Each tries to get away from its neighbour. Thus, independently of the downward pressure exerted by a gas in virtue of its weight, there is another pressure acting equally in all directions. This property is known as the expansibility, tension, or elastic force of gases.

This outward pressure depends upon the temperature and upon the compressing force.

At sea-level and at a temperature of 0° C. (32° F.), the pressure of the atmosphere supports a column of mercury 760 mm. (30 in.) in height. A cubic inch of mercury weighs nearly half a pound. A difference of one inch in the height of the barometer would therefore indicate a difference of about half a pound to the square inch.

The expansion that takes place in air by the rise of temperature for each degree Centigrade is 0·003665 of its volume. If air is heated in a closed space its tension rises, and if a barometer is in the closed space the mercury goes up. In the open, however, the air expands in volume, and its density is diminished. Therefore, as a matter of fact, a rise of temperature coincides with a fall in the barometer.

We have already seen that water-vapour is much lighter than air, having a specific gravity of 0·623 compared with air as unity. Hence when this light vapour is added to air, the resultant density is less than the density of air alone. In other words, moist air is lighter than dry air. Therefore the presence of moisture in the air under ordinary circumstances causes a fall in the barometer.

The pressure of the air at sea-level is taken as 760 mm. (30 inches), the mean pressure about 45° north latitude. Owing to the joint action of gravity and of centrifugal force, however, the pressure (or weight) of mercury is greater by about 4 millimetres (3·94 mm.) at the Pole than at the Equator. Consequently the barometric reading at the Pole is lower, and at the Equator higher by nearly 2 millimetres than would be the reading of an aneroid barometer, which corresponds to a spring balance, and is therefore unaffected by gravity.

As mentioned above, the pressure of the air diminishes with height. For as we ascend, not merely is the overlying column of air less, but the air itself is lighter. This lessened pressure takes place at a definite rate. A fall of 1 inch in the barometer corresponds roughly to a rise of about 300 yards above sea-level, and $\frac{1}{12}$ of an inch in pressure would correspond to the difference between the ground floor and the fourth story of an ordinary house.

The rate of diminution, being to some extent dependent upon temperature, is only roughly represented by these figures.

The following table shows the comparative pressure of air and of vapour at various degrees of humidity and at different temperatures at sea-level and at an elevation of 1550 metres. The weight of 1 cubic metre of air—dry and moist—at sea-level (760 mm.) and at a height of 1550 metres (630 mm. barometric pressure) is calculated :—

WEIGHT OF DRY AND OF MOIST AIR.

| | Temp. | Humidity. | Pressure in mm. | | | Weight in Grammes per cubic metre. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Dry Air. | Vapour. | Air and Vapour. | Dry Air. | Vapour. | Air and Vapour. |
| | ° C. | Per cent. | | | | | | |
| Sea-level . . | 0 | 0 | 760 | 0 | 760 | 1293·2 | 0 | 1293·2 |
| | | 50 | 757·7 | 2·3 | ,, | 1289·0 | 2·4 | 1291·4 |
| | | 75 | 756·55 | 3·45 | ,, | 1287·1 | 3·66 | 1290·8 |
| | | 100 | 755·4 | 4·6 | ,, | 1285·2 | 4·8 | 1290·0 |
| ,, | 15 | 0 | 760 | 0 | 760 | 1225·5 | 0 | 1225·5 |
| | | 50 | 753·65 | 6·35 | ,, | 1215·6 | 6·38 | 1222·0 |
| | | 100 | 747·3 | 12·7 | ,, | 1205·4 | 12·76 | 1218·2 |
| Davos, 1550 metres above sea-level | 0 | 0 | 630 | 0 | 630 | 1071·8 | 0 | 1071·8 |
| | | 50 | 627·7 | 2·3 | ,, | 1067·2 | 2·4 | 1069·6 |
| | | 100 | 625·4 | 4·6 | ,, | 1064·0 | 4·8 | 1068·6 |
| ,, | 15 | 0 | 630 | 0 | 630 | 1016·0 | 0 | 1016·0 |
| | | 50 | 623·65 | 6·35 | ,, | 1005·7 | 6·38 | 1012·0 |
| | | 100 | 617·3 | 12·7 | ,, | 995·5 | 12·76 | 1008·0 |

The following table compares the weight of air at sea-level at various temperatures, with air at various altitudes and 0° C. temperature. It shows, for example, that 1 cubic metre of air at sea-level at a temperature of 25° C. has the same weight as 1 cubic metre of air at an altitude of 698 metres (at 0° C.), namely, 1184·8 grammes, and that in both cases 1 mm. barometric pressure corresponds to a column of air of 11·47 metres height:—

[TABLE

RELATION BETWEEN PRESSURE AND TEMPERATURE OF THE AIR.

| Temperature at sea-level. 760 mm. pressure. | Elevations. | | Weight of Air in grammes per cubic metre. | Height of a column of Air representing 1 mm. pressure. |
|---|---|---|---|---|
| | Height over sea-level. | Pressure in mm. at 0° C. | | |
| ° C. | Metres. | | | Metres. |
| 0 | 0 | 760 | 1293·2 | 10·51 |
| 5 | 143 | 746·4 | 1270·0 | 10·7 |
| 10 | 285 | 732·2 | 1247·5 | 10·9 |
| 15 | 425 | 720·5 | 1225·9 | 11·08 |
| 20 | 563 | 708·2 | 1205·0 | 11·27 |
| 25 | 698 | 696·3 | 1184·8 | 11·47 |
| 30 | 830 | 684·8 | 1165·2 | 11·66 |
| 35 | 960 | 673·7 | 1146·3 | 11·85 |
| 40 | 1090 | 663·0 | 1128·1 | 12·04 |

During the course of the day the pressure is highest as a rule in the morning about nine, then it falls towards mid-day, and rises again in the evening. These changes depend upon the amount of heat received by the earth's surface, the pressure falling as the temperature rises.

The distribution of pressure over the earth's surface is a subject of great interest. It is graphically represented by what are called isobars, or lines of equal pressure. In certain places the pressure is usually high; for example, between the 30th and 40th degrees of latitude in both hemispheres where the high currents from the Equator descend. Over the interior of continents the pressure is usually high in winter and low in summer, the difference amounting to about 30 millimetres in some portions of East and Central Asia.

## WIND

Wind is air in motion. In spite of its variability and seeming irregularity when regarded only over a small area, its action is extremely regular when viewed as a whole. We will consider the laws that govern its movements.

Why should the air move? We have seen that when air is warmed it expands; in expanding it becomes lighter and ascends. Cold air from other places flows in to supply the place left by the ascending column. This simple explanation is the key to the great system of wind circulation over the face of the earth. At the Equator, the strongly heated air ascends to a great height and divides into two currents, one flowing to the North Pole and one to the South. The return currents from the poles coming from colder zones flow along the surface of the earth. These under currents over the great oceans are known as the Trade Winds; the upper currents as the Anti-Trades.

The direction of these currents, it might be supposed, would be due north and south. But this is not the case. Why? The atmosphere revolves with the earth, and at the same rate. Now the revolution of the earth is from west to east. The Equator passing through a much larger circle than the Poles in a given time has necessarily a much higher rate of speed. The equatorial air in flowing towards the Poles retains its original velocity of movement from west to east. But the places between the Equator and the Poles occupying a smaller circle are moving in the same direction at a slower rate. Hence the wind flowing from the Equator to the North Pole seems at intermediate places to come from the south-west; and wind flowing towards the South Pole seems to come from the north-west. On the return journey from the Poles the air starts with the low velocity of the smaller circles, and successively reaches places having a higher speed. The polar currents then seem to come partly from the east as well as from the north and south respectively.

Before taking this polar journey the air rises to a great height at the Equator—higher in fact than the peaks of the highest mountains. The direction it takes is known by clouds. As it travels on, it gets lower and lower, and descends to the surface of the earth somewhere about the 30th degree of latitude in both hemispheres, where part of it continues its journey towards the Pole, and part of it begins its return journey to the Equator.

This system of circulation goes on with perennial regularity, only a small zone near the Equator being subject to a reversal of the current according to the season. Only over vast surfaces of water do the laws affecting winds work without interference. Over the surface of continents many new factors come into play. Mountains, lakes, forests, the form of the ground, and the irregular distribution of land and water, give rise to variations of temperature and of moisture, which make the winds much more irregular in their occurrence.

The monsoons are the chief type of what are known as periodical winds.

The Equator is not really the line of greatest heat. Owing to the much greater amount of land in the northern hemisphere than in the southern, the line of greatest heat is a little north of the Equator. Over the Atlantic and Pacific Oceans this deviation northwards is too inconsiderable to be of account. But over the Indian Ocean the circumstances are different. To the north of the Indian Ocean is first a large tract of low country, and then a range of high mountains. The low country receives the great heat of a tropical sun, while it is protected by the mountains from the cold north winds. As might be expected, during the summer months the line of greatest heat in this district is carried far northwards, and the winds in the southern hemisphere coming from the south-east to the Equator have to travel farther north.

Thus the winter monsoon blows from 30° north latitude in India as a north-east wind towards the Equator, crosses the line, and blows from the north-west as far as 20° south latitude on the coast of Australia, the change from east to west being of course due to the greater speed of revolution at the Equator. During the northern summer months, the line of heat being shifted to the north, the south-east trade wind extends up to the Equator, and passing to the northward of it becomes the south-west monsoon.

Winds of less importance to the metereologist, but of great importance to the physician, are local currents, which, in comparison with the systems just described, are hardly

more than draughts of air. These local winds are in some cases periodical, in others simply the winds of most frequent occurrence.

Land more quickly than water becomes cold by radiation, and hot by exposure to the sun. During the day, therefore, the cold air or sea breeze flows to supply the place of the heated air ascending from the land. At night, the conditions being reversed, the wind blows from land to sea.

Another type of periodical wind is found in the interior of continents. As the ground becomes heated by the sun, the air ascends and creates thus an area of low pressure. To restore equilibrium, denser air rushes from a distance, the direction of the current depending on the configuration of the ground. During the night the air cools, contracts, and no longer ascends. Equilibrium is thus established, and the wind ceases. Usually a wind blows at night in the opposite direction to that of the day wind.

In some places the configuration of the ground is such that these winds occur with the utmost regularity; and nothing short of a great atmospheric disturbance alters the course of events. In other places the shape and constitution of the surface only slightly favour one wind rather than another; but the one that blows oftenest is spoken of as the prevailing wind.

Many points concerning the circulation of wind, interesting to metereologists, but of little value to the physician, must be passed over in silence. Only one need be mentioned here: Buys Ballot's law. It has been found that storms consist of a centre of low pressure around which denser air circulates. If in any place the atmospheric pressure is low, air rushes from all sides to restore the equilibrium. In accordance with the greater velocity of movement at the Equator, than at the Poles, winds in the northern hemisphere, flowing northwards, acquire a direction from west towards east, and winds flowing southwards, a direction from east towards west. The consequence of this is to give a circular movement, contrary to the direction of the hands of a watch, to winds round a centre of low pressure.

From a centre of high pressure air flows away in every direction, and, according to the law already stated, winds flowing northwards take a direction from west to east; winds flowing south, from east to west. The result is to give a circular movement, with the hands of a watch, to winds flowing round a centre of high pressure.

The direction of the currents is exactly the opposite in the southern hemisphere.

The winds round a low pressure centre are spoken of as a cyclonic system; round a high pressure centre as an anti-cyclonic system.

The point of low pressure or storm centre may travel for hundreds of miles surrounded by circular currents.

The temperature and the relative moisture of winds depend upon their place of origin. Coming from the ocean near the Equator they are warm and laden with moisture. Coming from the Arctic regions, on the contrary, they are cold and dry. Warm moisture-laden winds when they meet with colder air become themselves cold to their saturation point and beyond it. In this way clouds are formed; but the condensation produced is seldom sufficient to cause rain.

In illustration we may take the monsoon of India, already referred to. The north-east monsoon blowing down from the continent to the Equator is a dry wind. In crossing the Equator it becomes laden with moisture, and in descending to the Australian coast it carries with it abundance of rain, while the south-west monsoon, in going from the Equator to India, becomes charged with moisture and deluges the adjacent portion of the continent with a heavy downpour.

Mountains also discharge the water-vapour from winds. The air as it is driven up the mountain sides comes under a very much diminished atmospheric pressure, and therefore expands. As it expands, its heat is converted from sensible into latent. As it is cooled, its capacity for holding moisture is diminished. A warm moist wind in passing over a mountain is thus cooled and dried. When it has crossed the mountain tops it again descends. In descending, it comes under high atmospheric pressure and is squeezed

into a smaller bulk, and the latent heat is again given out as sensible heat. But now it is no longer moist, but excessively dry. In the Alps such a wind is known as the Föhn.

For a long time it was believed that the Föhn had its origin in the desert of Sahara; but it has now been established by simultaneous observations of the wind at different places that the explanation is what has just been given: that the Föhn was originally a moisture-laden current that has just discharged its load of water. To Hann the credit of this discovery is chiefly due. Further details are given later on (p. 54).

The scale devised by Admiral Beaufort in 1805 for indicating the force of the wind is still in general use at sea. Since then a great many other scales have been put forward; and a comparison of the values represented by the various figures is by no means a simple matter. The following table[1] show the results arrived at by various observers in attempting to express the strength of the wind by its velocity. English miles per hour are converted into metres per second by multiplying by the factor 0·447 :—

BEAUFORT WIND SCALE.

| Strength of Wind. | Expressed in metres per second. | | Miles per hour. | |
|---|---|---|---|---|
| | After Scott. | After Sprung and Köppen. | Scott. | Sprung and Köppen. |
| 0. Calm . . . | 1·5 | 1·0 | 3 | 2·23 |
| 1. Light air . . | 3·5 | 2·8 | 8 | 6·26 |
| 2. Light breeze . . | 6 | 4·1 | 13 | 9·1 |
| 3. Gentle breeze . | 8 | 5·4 | 18 | 12 |
| 4. Moderate breeze . | 10 | 6·8 | 23 | 15·2 |
| 5. Fresh breeze . | 12·5 | 8·4 | 28 | 18·8 |
| 6. Strong breeze . | 15 | 10·2 | 34 | 22·8 |
| 7. Moderate gale . | 18 | 11·7 | 40 | 26·1 |
| 8. Fresh gale . . | 21·5 | 13·4 | 48 | 30·0 |
| 9. Strong gale . . | 25 | 15·3 | 56 | 34·2 |
| 10. Whole gale . . | 29 | | 65 | |
| 11. Storm . . . | 33·5 | | 75 | |
| 12. Hurricane . . | 40 | | 90 | |

Scott's figures are generally considered too high. Mohn[2] gives the following land-scale; and he remarks that a given velocity of wind will always be indicated by a relatively lower figure at sea than on land:—

| Force of Wind. 0-6. | Velocity of the wind. Metres per second. | Action of the Wind. |
|---|---|---|
| 0. Calm . . | 0-0·5 | Smoke rises straight or almost straight. |
| 1. Light . | 0·5-5 | Perceptible; moves a pennant. |
| 2. Moderate . | 5-9 | Extends a pennant; moves the leaves of the trees. |
| 3. Fresh . | 9-13 | Moves the smaller branches of the trees. |
| 4. Strong . | 13-17 | Moves the larger branches and weaker stems. |
| 5. Storm . | 17-28 | Moves the whole tree. |
| 6. Hurricane . | Over 28 | Destructive effects. |

## REFERENCES

1. Bartholomew's *Physical Atlas*, vol. iii., *Meteorology*, Edinburgh and London, 1899, p. 39.
2. H. Mohn, *Grundzüge der Meteorologie*, 5te Auflage, Berlin, 1898, S. 172.

# CHAPTER V

## ELECTRICITY

The investigation of atmospheric electricity dates from the time of Franklin. Careful observations prove that when electricity is not evident to the senses, it can be detected by means of instruments. The outcome of these observations is the knowledge that the atmosphere is as a rule positively electrified and the earth negatively.

The greatest distance at which a spark can be obtained from a powerful electric machine is not much more than 3 feet; while lightning flashes at a distance of a mile; and according to Scott a flash between clouds 10 miles apart has been observed. This will give some idea of the enormous force brought into action.

The precise cause of changes in electric potential have not yet been definitely made out. That the earth is negatively electrified is the most constant fact. Hence it follows that vapours ascending from it will have the opposite potential; and this probably is the way in which the air becomes positively electrified. In addition to evaporation, winds by virtue of friction with the earth, and clouds, and hail, and snow, either mechanically or by virtue of their change of form, tend also to alter the electric tension. Chemical and biological changes have no doubt a similar action.

Quetelet found at Brussels that the electricity varies in amount during the day: the maxima being about 8 A.M. and 9 P.M. in summer; and about 10 A.M. and 6 P.M. in winter. The day minimum is at 3 P.M. in summer; and 1 P.M. in

winter. The night minimum has not been exactly made out. The variations of electricity precede by about an hour those of the barometer. During winter, electricity is at its maximum, and during summer at its minimum, the phenomena being thirteen times more active in January than in June. The records at Kew, Greenwich, Lisbon, and other places, show a more or less general resemblance to the same type. Exner found that at all seasons of the year the potential gradient near the surface of the earth diminishes regularly with increased tension of water-vapour.

As already stated the air is generally positive; but during storms changes are rapid, frequent, and violent. Negative electricity betokens rain; but positive electricity does not necessarily indicate fine weather. The electric potential increases with elevation over hills, mountains, or towers; but diminishes with elevation in free air, as when measured by a captive balloon.

Concerning radio-activity Dr. Saake[1] made some remarkably interesting observations in Arosa, 6000 feet above sea-level, during the months of February, March, and April. He found that on an average the air contained three times as much radio-active emanation as did the air in the lowlands (Wolfenbüttel), and that the maximum might be five times as much as in the lowlands.

REFERENCE

1. Dr. Saake, "Ein bislang unbekannter Faktor des Höhenklimas," *Münch. med. Wochenschrift*, January 5, 1904.

## CHAPTER VI

### GENERAL INFLUENCES AFFECTING CLIMATE

In the preceding pages we considered each factor of climate in relation to the circumstances that modify it. We will now take each of these modifying circumstances in turn, and show its influence in connected form on the factors of climate together; in other words, on climate generally.

We will begin with the great division of the earth into land and water; and consider how temperature, moisture, and wind are modified thereby.

The characteristics of land climates and of sea climates respectively have first to be considered; then the influence that they exercise on each other.

We have already seen that the specific heat of water is greater than that of any other substance on the face of the earth. It becomes more slowly heated and parts with its heat less rapidly. In addition to this, we have seen that it has a remarkable power of absorbing heat in its conversion from the solid into the liquid, or from the liquid into the gaseous state. As it returns from the gaseous to the liquid, and from the liquid to the solid state, heat is again set free.

The specific heat of the solid portion of the earth is 0·2, compared with water as unity. Thus, when the same extent of surface of land and of sea receive the same amount of heat, the surface of the land becomes much hotter than the water. Moreover, the rays falling on the water pierce it to a great depth, and so are to a large extent lost for the surface. About one-half of the heat

coming from the sun, it has been calculated, is spent in transforming water into vapour. This heat is lost to the lower strata of air, but is a source of heat for the higher strata, where it is given out again when the vapour condenses.

The land, which becomes so quickly heated, parts as quickly with its heat; and at night becomes very much colder than the water. The result, therefore, is that over the interior of continents the range of temperature is great, while over the oceans it is extremely small. A table from Hann,[1] showing the mean temperatures in the 52nd degree of north latitude from west to east, from the sea inwards over the land, illustrates this point in a striking manner:—

| Place. | North Latitude. | Longitude. | Temperature in ° C. (reduced to sea-level.) | | | |
|---|---|---|---|---|---|---|
| | | | Year. | January. | July. | Difference. |
| Valentia | 51°54′ | 10°25′W. | 10·1 | 5·7 | 15·1 | 9·4 |
| Oxford | 51°46′ | 1°16′W. | 9·4 | 3.6 | 16·2 | 12·6 |
| Münster | 51°58′ | 7°38′E. | 9·1 | 1·3 | 17·3 | 16·0 |
| Posen | 52°25′ | 17°5′ E. | 7·8 | − 2·7 | 18·3 | 21·0 |
| Warsaw | 52°13′ | 21°2′ E. | 7·3 | − 4·3 | 18·7 | 23·0 |
| Kursk | 51°45′ | 36°8′ E. | 5·7 | − 9·4 | 19·8 | 29·2 |
| Orenburg | 51°46′ | 55°7′ E. | 3·5 | − 15·3 | 21·6 | 36·9 |
| Barnaul | 51°52′ | 80°30′E. | 1·7 | − 18·0 | 21·8 | 39·8 |

Thus the continental type of climate is characterised by great range of temperature, with excessive heat in summer and excessive cold in winter. The insular type, on the contrary, is represented by moderate range of temperature and absence of extremes either of heat or of cold.

The influence of land and of water respectively on temperature varies also with the latitude, being much greater near the Equator than towards the Poles. Another table from Hann,[2] showing the temperature over land and

over water respectively from the equator to the 50th degree of north latitude, illustrates this :—

| | Equator. | 10°. | 20°. | 30°. | 40°. | 50°. |
|---|---|---|---|---|---|---|
| Land . . | 44·8° | 42·5° | 36·4° | 26·0° | 15·7° | 3·6° C. |
| Water . . | 22·2 | 21·2 | 19·6 | 17·4 | 12·7 | 7·6 |
| Difference . | 22·6 | 21·3 | 16·8 | 8·6 | 3·0 | – 4·0 |

The daily oscillations of temperature as well as the yearly are much greater over land than over sea; the oscillations increasing as the Equator is approached. In the interior of South Africa and of Australia the daily range of temperature is perhaps higher than elsewhere. On December 25, 1878, Rohlfs found the morning temperature at Bir Milrha (south of Tripoli, 314 metres above sea-level) – 0·5° C., while in the afternoon his thermometer registered 37·2° C., that is a difference of 37·7° C. In the Algerian Sahara, Dr. Perrier found on May 25, 1840, frost on the ground about his tent in the morning, while at 2 o'clock the thermometer in the shade marked 31·5° C. Again, in North-West Australia on June 2 at sunrise, the temperature, according to Mitchell, was – 11·6° C., while at 4 o'clock in the afternoon it was 19·4° C. In such circumstances, the surface of the ground commonly reaches 70° C. to 80° C.[3]

In marked contrast with this is the range of temperature over the ocean. According to numerous observations in the Atlantic Ocean, between 0° and 10° north latitude, the daily oscillation of temperature amounts only to 1·6° C., and the range for a month is only 6·5° C.

The influence of lakes or large inland seas is very much the same as that of the ocean. A large body of water absorbs an immense amount of heat. In doing so it lowers the temperature of the air during the hot season, and during the period of greatest cold this heat is slowly given out and the air is thereby warmed. The average temperature of

the year in the neighbourhood of lakes, such as the Lake of Geneva for example, is two or three degrees higher than it would otherwise be.

Winds passing over water take up moisture according to their temperature. If the wind is warm it takes up much moisture, becoming at the same time somewhat cooled. A cold wind, in like manner, becomes somewhat warmed in passing over water warmer than itself. Moisture-laden winds precipitate water in passing over land. The precipitation may be brought about in various ways. Over a highly-heated surface of ground ascending currents of air are produced. As the air ascends, expansion with consequent cooling takes place; and if the relative humidity at the outset was near the saturation point, a downpour of rain is the result. Air may be forced to rise, not by the heating of the surface below, but by mountain ranges in the track of the wind. The result in regard to expansion, cooling, and rain is the same as in the previous case.

Forests and copious vegetation over a low-lying country cause precipitation in a different manner. The vegetation prevents the excessive heating of the ground, and at the same time promotes evaporation. A warm moist wind in passing over a forest is likely to be cooled beyond saturation point. Thus fogs and clouds occur in abundance, with frequent drizzling rains rather than occasional heavy downpours. The British Islands afford an example of this type.

This discharge of moisture, the condensation of vapour to the liquid state, sets free a very large amount of latent heat—from 607 to about 580 Calories for every kilogramme of water condensed at the temperatures between which, roughly, rain occurs. Such conditions are a source of heat in winter; but clouds, fogs, and evaporation diminish the heat of summer.

Another consequence of the juxtaposition of land and sea is the springing up of the local currents known as sea-breezes and land-breezes. During the day air flows from

the sea to the heated land; during the night from the cooled land to the relatively warm sea. Such breezes impart to coast lands some of the character of an ocean climate, diminishing the range of temperature and increasing the humidity.

It might be expected that aqueous vapour would be present in much greater abundance over the ocean than over the land, and this in fact is true: but the difference is not by any means so great as is commonly supposed. Even over deserts the absolute amount of moisture in the air is nearly as great as close to the sea. The average humidity in July over the steppes and deserts of south-west Siberia and west Turkestan is represented by a pressure of 11 mm. of mercury, which is the humidity of the air in Vienna or Paris in July, and very little less than that of the west coast of Europe in the same latitude. According to Rohlfs, in the oasis of Kauar in the heart of the Sahara Desert, 18° 8′ north latitude, the atmospheric vapour tension in May was 13 mm. Hann,[4] from whom I take these figures, remarks that Lichtenberg was not so far wrong in saying that if we could make cold as easily as we make fire, we could without difficulty even in the midst of the desert procure water from the atmosphere.

Although the quantity of water-vapour actually present in the air inland is nearly the same as on the sea coast, it is usually much less than what the air would hold. In other words, while the absolute moisture is not small, the relative moisture may be extremely low, varying from 25 per cent to 50 per cent. These remarks, however, refer only to summer. In winter, in the middle and higher latitudes, the air over the interior of continents contains very little moisture absolutely, but that little suffices to bring it near its saturation point, nearly all the water being condensed out of the air through the great cold. In the south-west of Siberia and Turkestan in January the vapour tension is only 1·7 mm., while the relative humidity is 86 per cent. In lower latitudes, however, in winter as well as in summer, the air over the interior of continents is relatively dry.

According to Rohlfs' observations, the average winter humidity for Murzuk in Tripoli, 25° 54′ north latitude, is 4·6 mm. vapour tension and 47 per cent relative humidity.[5]

Corresponding to the greater dryness of the interior of continents a less amount of cloud is to be seen.

We have now to look at the influence of mountains on climate. Here two points arise for consideration: first, the climatic characteristics of places situated in mountains; and, secondly, the influence of mountains on the neighbouring lowlands.

The temperature in the mountains stands in marked contrast with the temperature in the lowlands. The first thing that strikes an observer is the great intensity of the sun's rays as compared with the temperature of the air. The radiant heat of the sun is much greater than in the lowlands. In the previous pages we saw that some of the rays of the sun are absorbed in passing through air, and the amount so absorbed is great in proportion to the quantity of water-vapour present. We saw also that with the expansion of air in ascending the temperature falls, and that consequently the capacity of the air for moisture is much diminished. As a result of the diminished amount of moisture in the air, comparatively little obstruction is offered to the rays of light and of heat. Two or three examples may be given. In the Himalayas, at a height of between 3000 and 4600 metres, Hooker found that at 9 A.M. in winter the black-bulb thermometer registered 55·5° C., whilst at the same time the temperature of the snow in the shade was 5·6° C. At Mount Whitney (Sierra Nevada, U.S.) between 4000 and 5000 metres above sea-level, the radiant heat of the sun was so great, according to Langley, that the temperature in a copper vessel covered with two glass plates rose above the boiling point at the place.[6] The intensity of the chemical rays of the sun, which are greatly hindered by aqueous vapour, rises in like manner. Bunsen and Roscoe have calculated that the chemical intensity at the borders of the atmosphere equals 35·3 "light metres"; that is to say, the

sun's rays would, when falling perpendicularly through an unlimited quantity of chlorine gas and hydrogen, form in one minute a layer of hydrochloric acid 35·3 metres thick. From Hann[7] I borrow a table showing the chemical intensity of the sun's rays at various heights above sea-level.

PERCENTAGE OF THE MAXIMUM CHEMICAL INTENSITY OF THE SUN'S RAYS.

| Barometric pressure. | Height above sea-level. | Height of sun above Horizon. | | | | |
|---|---|---|---|---|---|---|
| mm. | Metres. | 90° | 70° | 50° | 30° | 10° |
| 750 | 130 | 44 | 42 | 34 | 19 | 1 |
| 650 | 1270 | 49 | 47 | 39 | 24 | 2 |
| 550 | 2600 | 55 | 53 | 46 | 30 | 3 |
| 450 | 4200 | 61 | 59 | 53 | 37 | 6 |
| 350 | 6200 | 68 | 67 | 61 | 46 | 10 |

In consequence of the smaller absorption of the sun's rays in the mountains the surface of the ground becomes comparatively more highly heated than in the lowlands. A comparison between the heat of the air and the heat of the ground on the Faulhorn and at Brussels has been made by C. Martins.

TEMPERATURE AT 9 A.M. BETWEEN AUGUST 10 AND 18, 1842.

| Place. | Height. | Air. | Surface of the Ground. |
|---|---|---|---|
| | Metres. | °C. | °C. |
| Faulhorn . . . . | 2680 | 8·2 | 16·2 |
| Brussels . . . . . | 50 | 21·4 | 20·1 |

By these two peculiarities, the greater intensity of the sun's rays and the greater heat of the ground, mountain climates are distinguished from the climate of the polar regions of similarly low temperature.

We have already seen that the temperature of the air

diminishes as we ascend, and that apart from disturbing influences, such as the condensation of vapour, the rate of diminution due to the expansion of the air would be 1° C. for every 100 metres. The rate of diminution in mountainous districts is on the average 0·58° C. for every 100 metres, but varies according to circumstances. On the south side of the Alps, for example, the rate of diminution is 0·69° C., and on the north side 0·55° C., the difference being due to the different exposure to the sun.

We have seen also that in certain circumstances there is an increase instead of a diminution of temperature for some distance above the ground. This occurs normally at night, but to the most marked degree in high mountain valleys, where it may occur during the day in winter. The explanation has already been given. During clear bright nights, and during the day when the surface is covered with snow, the air, cooled by contact with the ground, contracts and does not tend to rise. At the same time radiation from the earth's surface is rapid—for even snow is warm in comparison with the temperature of interplanetary space; and the comparatively dry air offers little impediment to the dispersion of heat. The heat so radiated passes partly into space and is partly arrested by what aqueous vapour is present.

The variations of temperature in mountain districts present many points of interest. In the upper strata of the atmosphere the oscillations of temperature become less and less, and ultimately, no doubt, a point is reached where an absolutely uniform temperature prevails. Isolated mountain peaks exhibit the nearest approach to this condition, and thus afford an important feature of resemblance to the climate of the sea coast; though the cause of this common feature is exactly the opposite in the two cases. In valleys, on the contrary, and on elevated plateaux the daily range of temperature as a rule is high. In North Tibet, for example, in December the range of temperature between 8 A.M. and 1 P.M. is 17·3° C. In Pamir (Turkestan) 3600 to 4000 metres high, in August and September

the range is about 25° C. In St. Louis on the Mississippi between 7 A.M. and the afternoon maximum, the range of temperature is only 6·5° C., while on the elevated plateau to the west, 2000 feet high in the same latitude, the range during the same hours is 11° C., and the daily oscillation between 16° and 18° C.

The yearly range of temperature also in the mountains is less, the difference between the average temperature of the coldest and of the warmest month being less than in the same latitude in the lowlands.

A peculiarity of the daily range of temperature in the mountains is that the maximum occurs almost about midday, while in the lowlands the maximum occurs about 2 P.M. This is accounted for by the intensity of the radiant heat of the sun as already mentioned.

Another circumstance that greatly influences climate in the mountains is snowfall. By the condensation of vapour into snow an enormous amount of heat is set free. While the snow lies on the ground the heat rays of the sun are partly reflected and partly used up, not in warming the air or in warming the surface, but in the mechanical work of converting snow into water or vapour. In this way the heat of the sun's rays is for the time entirely lost. During the snow-melting period a vast amount of heat is absorbed in this way.

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### Influence of Mountains on Humidity

Many of the peculiarities of mountain climates are due to conditions of atmospheric humidity. As we have seen in a previous page, most of the water-vapour in the air is collected in the lower strata, not because it is heavier,—for, in fact, the contrary is the case,—but because, owing to the greater cold as we ascend, the moisture is condensed out of the higher strata. In a general way this law holds good for the air over the sea and over a level inland country. Mountains, however, form a disturbing element, the air over them being unequally heated. As a rule, however, in mountains also the absolute moisture in the air diminishes

with the height, though not with the same regularity as over the lowlands.

With the relative moisture the case is different, and in regard to it hardly any general statement can be made. It will readily be seen that the conditions are very unlike over a solitary peak, a range of mountains, a high plateau, and an elevated valley; and the relative moisture is entirely dependent upon the local conditions.

The amount of cloud and the amount of rainfall stand in close connection with the relative moisture of the air. Owing to the great inequalities of heat in different parts of mountains, clouds readily form and disappear; and the rainfall is great as compared with that of the lowlands.

Most mountain ranges have a wet side and a dry side; moisture being deposited on the slopes that receive moist winds from the sea, while these winds when they have crossed the mountains are dry and warm. The rainfall of the west of Scotland, for example, ranges from 120 to 300 centimetres; the rainfall of the east of Scotland is 60 to 80 centimetres. The north side of the Bernese Alps has a rainfall of 150 centimetres; while the south side in the Rhone valley receives only from 60 to 90 centimetres. Single mountain peaks cause the moisture in warm air passing over them to be condensed, and for this generally have the character of weather prophets.

In tropical countries, during the rainy season, at a certain definite height there is a layer of almost constant saturation. In the Himalayas this layer is at about 3000 or 4000 feet. In the ranges of higher latitudes in winter a similar layer is apt to form about the foot of the mountain. Above the saturation level the moisture, both relative and absolute, is small. On peaks of mountains and in exposed places the changes in the relative moisture are rapid and extreme. In regard to this point Junghuhn's [8] psychrometric observations on the peaks of mountains in Java are of the greatest interest. On the Grand Slamat (3374 metres above sea-level) the average relative moisture from June 20 to 22 was 52 per

cent, but it varied between 13 per cent and 100 per cent. In valleys, however, and in sheltered places, the changes are by no means so violent.

Winter and summer in high mountains stand in marked contrast not only to each other, but also to the same seasons in the lowlands. Winter, owing to the coldness of the air, and to its consequent extreme dryness, is characterised generally by a clear sky and by intense solar radiation. In summer, on the contrary, there is a tendency to the formation of clouds in the afternoon, with perhaps a heavy downpour of rain or a thunderstorm, and during the finest weather this is apt to occur with regularity. The explanation we shall find a little later in speaking of mountain winds.

Another important peculiarity of mountain climates in regard to moisture is the greater rapidity of evaporation. At the same temperature, and at the same degree of relative saturation of the air, evaporation takes place with greater rapidity in proportion to the elevation. Not merely is the evaporation greater, but the vapour thus formed is diffused more rapidly. Both of these circumstances are simple examples of the well-known physical law that evaporation and diffusion are greater as pressure is less.

### Atmospheric Pressure on Mountains

The general laws governing atmospheric pressure have been already stated. The pressure diminishes with the height. The only point that need be referred to here is the contrast between the yearly march of barometric pressure in the mountains and in the lowlands. In the lowlands the barometer stands highest in winter and lowest in summer. In the mountains the case is reversed, the pressure being greater in summer than in winter. The explanation is simple. In the lowlands the air near the ground is relatively more expanded in summer and more contracted in winter than is the air at some elevation above the surface. When the lower portions

of the column are dense, the entire column will be heavier than when they are expanded; but the weight of a column above a given elevation will be greater when the expanded lower portion has driven upwards the layers lying above it.

## Wind in Mountains

Some of the most remarkable features of mountain climates are due to peculiarities of wind. The winds of greatest interest are—first, the local valley winds; and secondly, the modifications of the great circular wind currents—such, for example, as the Föhn in Switzerland.

The main characteristic of the valley wind is that, as a rule, it blows up the valley during the day, and down the valley during the night. Only in cases of considerable atmospheric disturbance is its regularity interfered with. The explanation of the up-current was for a long time a puzzle. It was thought that the air, expanded by the heat of the sun, should rise more or less vertically; as a matter of fact, however, its upward course is parallel to the surface of the valley. The air at the same horizontal level a little lower down the valley not being in contact with the ground still remains unexpanded and flows to supply the place of the ascending air. The same process repeated along the whole surface of the incline gives rise to the current in question. In other words, a kind of aspiration or suction forces or draws the wind upwards along the surface. The down-current at night is due to the reversal of this process, the contracting air descending. Certain seeming exceptions really establish the accuracy of this explanation. In the Upper Engadine the valley wind blows downwards during the day and upwards during the night. This valley opens into another, the Mairathal, leading down into Italy, in which the general law holds good. The slope in the Mairathal is steeper; and the ascending current into the valley with gentler slope thus overcomes the tendency there to a current in the opposite direction. The Davos valley also affords an exception to the general law. But here the

up-current from the Prätigau valley just balances the up-current tendency of the Davos valley, causing windlessness.

These valley winds explain also the occurrence of afternoon rain and thunderstorms during the summer season in mountains. The moisture in the low-lying parts of the valley is carried up with the current of air. As this air ascends into higher regions it expands, and consequently becoming colder, the moisture contained in it is condensed. Thus in the afternoon clouds form, and frequently a heavy downpour or a thunderstorm is the result. To a person unfamiliar with mountains the strangest part of the phenomenon is to follow: as the sun goes down the sky clears. This has been a source of wonder to most meteorologists on first becoming acquainted with the fact. The explanation is simply this. The descending current having set in, the moisture taken up in the ascending current is now carried downwards. Hence, though the sky becomes clear, the lower portion of the atmosphere is apt to assume a hazy appearance, and in some cases in the low-lying parts of the valley a heavy mist forms.

The Föhn of Switzerland is a wind of the greatest interest. It is warm and excessively dry; and for a long time it was supposed to blow from the Desert of Sahara. Modern investigations have shown that this supposition is incorrect. Not merely is the Föhn more frequent in winter when the winds of the Sahara are not hot, but direct observation has shown where it comes from. When a centre of low pressure exists on the west or north-west of the Alps in a line between the Bay of Biscay and Ireland, winds from the Atlantic Ocean have been found, in accordance with the rotatory motion of storms, to come over Switzerland more or less from the south. Independently of this, it is found that, in general, a cold and moist wind on the windward side of a mountain chain appears on the leeward side hot and dry. From this explanation it follows that winds having the same characteristic are found in all mountain regions: the essential point being that a wind having discharged its moisture in crossing over a chain

of mountains descends dry and hot into a valley on the leeward side.

An example is given here from Hann,[9] which illustrates the point mentioned.

WEATHER ON THE GOTTHARD PASS DURING THE FÖHN OF JANUARY 31 AND FEBRUARY 1, 1869.

| Place. | Height. | Temperature. | Humidity. | Wind, Direction, and Force (1-10). |
|---|---|---|---|---|
| | m. | | Per cent. | |
| Bellinzona . | 229 | 3·0° C. | 80 | N. (rain) |
| S. Vittore . | 268 | 2·5 | 85 | S. and S.-W. |
| Airolo . . | 1172 | 0·9 | ... | N. and S. |
| St. Gotthard . | 2100 | – 4·5 | ... | S. 2-3 |
| Andermatt . | 1448 | 2·5 | ... | S.-W 2 |
| Altdorf . . | 454 | 14·5 | 28 | S. (Föhn) |

Wettstein[10] gives the following as the average frequency of Föhn days during seven years in the north of Switzerland :—

| | Winter. | Spring. | Summer. | Autumn. | Year. |
|---|---|---|---|---|---|
| Number of days | 9·1 | 17·3 | 4·9 | 9·6 | 40·9 |

Other local winds will be considered when we deal with types of climate.

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# PART II

# PHYSIOLOGY OF CLIMATE

# CHAPTER VII

## GENERAL CONSIDERATIONS

It is worth considering for a moment in what way we obtain knowledge of the physiological action of climate.

The sources of our information are threefold:

(1) Deductions from general physiological principles;
(2) Experiments on men and animals;
(3) Observations on men and animals who have lived in climates of different character.

The general physiological principles involved concern the production and removal of heat, and the great principle of the Conservation of Energy, whereby the equivalent of heat in mechanical force is estimated.

Experiments on men and animals test the soundness of the speculations reached by deductions from physiological principles. Experiments have been conducted by various observers, which show that the production of work and of heat in the animal organism conforms to the same laws as in any other machine. A given quantity of bread, of meat, or of potatoes, gives rise to the same amount of heat or of mechanical energy, whether it is burned rapidly as in the air or in pure oxygen, or slowly, as in the tissues.

The quantity of heat produced, the places of its formation, the mechanism of its production, of its removal, and of its transformation into mechanical energy, have all been estimated by direct experiment. Though these points have been tolerably well worked out, we still have but imperfect knowledge concerning the means by which the production of heat is adjusted to the demand for it. The animal

organism is provided with a marvellous power of regulating the formation and the removal of heat. Though exposed to the widest differences of temperature, warm-blooded animals preserve their body heat practically unaltered. This has been a source of wonder and of admiration from the time of the earliest observers to the present day. Though the laws governing the regulation of heat have, as already said, been pretty thoroughly made out, the mechanism that presides over these laws still remains in obscurity.

The information obtained from the study of animals in zoological gardens and from physiological observations by travellers on themselves is of the highest importance.

## Constituents of the Atmosphere and their Physiological Influence

When speaking of the composition of the atmosphere, we found that in spite of the vast quantities of impurities constantly thrown into the air, very little variation occurs in regard to the essential constituents. A constant process of renewal goes on, and the slight variations that occur, though sometimes perceptible to the sense of smell, are hardly recognisable by the most delicate chemical reagent.

In this section the office of each of the component parts of the atmosphere will be considered.

### Oxygen

Oxygen is the essential constituent of the atmosphere, though forming only about one-fifth of its bulk. Oxygen is the agent by which the chemical changes essential to animal life take place. When air is drawn into the lungs, a portion of the oxygen is fixed by the hæmoglobin of the red corpuscles and is carried by the circulating blood into the remotest organs, where the actual oxidation or combustion of the tissues goes on. This is sometimes spoken of as internal respiration. The products of combustion, chiefly

carbonic acid in the case of carbohydrates and hydrocarbons, and chiefly urea in the case of nitrogenous stuffs, are excreted, the carbonic acid by the lungs, and the urea by the kidneys. The hæmoglobin, having yielded its oxygen to the tissues, takes up carbonic acid from them; and when it again reaches the lungs, the carbonic acid is displaced by the oxygen of the air.

This is a very rough and imperfect view of the changes that take place and of the function of oxygen in securing the renewal of tissues and the removal of effete products, but it is sufficient for our purpose so far.

The quantity of oxygen used up by a healthy man in the twenty-four hours depends upon many circumstances, such as the quantity of food ingested, the amount of work performed, the temperature of the body, and the external temperature. The amount is estimated as being on the average 822 grammes (575 litres) for a man at rest, and 1010 grammes (700 litres) when at work. The quantity of oxygen in arterial blood in dogs varies according to different estimates from 11·4 per cent to 20·4 per cent in volume. Under a pressure of one atmosphere, 6·4 per cent of the entire amount is in the plasma, the remainder in the hæmoglobin.

The proportions of the various gases in the blood at sea-level and at the freezing-point of water is roughly as follows:—

| | Oxygen. | Carbonic Acid. | Nitrogen. |
|---|---|---|---|
| In 100 volumes of arterial blood are | 20 vols. | 39 vols. | 1·8 vols. |
| „ „ „ venous „ „ | 12 „ | 46 „ | 1·8 „ |

Thus about 8 volumes, more or less, of oxygen are used up in the organism in each circulation of the blood. The influence of variations in the supply of oxygen will be considered more fully a little farther on under the head of Pressure. Here it need only be stated that the amount

actually turned to account in the organism depends mainly upon the requirements of the organism itself, not, as was formerly thought, on the abundance of supply.

### Nitrogen

Nitrogen is devoid of any physiological action whatever. Its function in the air is simply to dilute oxygen. The amount of this gas present in the blood is, as we have seen, one or two volumes per cent. It varies, however, according to Dalton's law, the amount increasing with the pressure. It is simply held in solution, and does not enter into chemical combination with the tissues.

When the atmospheric pressure is suddenly diminished, this gas plays a very important rôle. Dissolved in the blood under a certain pressure, it escapes when the pressure is lessened, and so leads to the formation of gas bubbles in various blood-vessels.

Workers in caissons deep under water are subjected to a pressure of two or more atmospheres. At one time, before the danger was understood, they were allowed to return direct from the compressed air to the ordinary atmosphere. Serious symptoms occurred, and in some instances even death took place. A fatal result was due, as Bert showed, to air emboli in the lungs. In cases of less severe type paralysis of the lower extremities was speedily developed, a symptom due to air bubbles in the blood-vessels supplying the cord.

### Argon

To argon no hygienic or physiological action can be ascribed. Krypton, neon, and xenon are in the same case.

### Carbonic Acid

The amount of carbonic acid ordinarily in the air is from three to four parts in every ten thousand. This quantity must be considered as having no physiological

action. Even as large a proportion as 1 per cent can be borne for some time without giving rise to disturbance; and air containing as much as 4 per cent has been breathed for ten minutes without harm.

Carbonic acid owes its evil reputation chiefly, not to its own bad qualities, but to its bad company. Where the atmosphere of a room has been vitiated by respiration to such a degree that the amount of carbonic acid is 3 per thousand, the air is distinctly unfit for breathing. The substances that cause this deterioration are unknown; but in such circumstances the carbonic acid serves as a measure of their amount. Air containing from 30 to 40 per cent of carbonic acid proves immediately fatal when a person enters it from the fresh air. The symptoms of poisoning from smaller quantities are generally paralysis and loss of consciousness.

This gas exists in the blood chiefly in chemical combination with the salts of soda and with the hæmoglobin. The portion united with the hæmoglobin is displaced by oxygen at each inspiration.

## Ozone

For a long time great importance was attributed to the ozone of the air; and even nowadays people not infrequently speak of air that they think good as containing a great deal of ozone. Increased knowledge of this curious body has completely overthrown these earlier views; and in the present state of science we are not warranted in ascribing to the atmospheric ozone any action whatever, either of a healthful or of a hurtful character, on the animal organism. Ozone, when present in the air at all, never exceeds in quantity $3\frac{1}{2}$ milligrammes in a 100 cubic metres, and is seldom more than half so much; and even this cannot be supposed to enter the blood. Such is the activity of ozone in combining with organic bodies, that it is already decomposed before it comes into contact with the blood stream. Even supposing that it gets as far as the

alveoli of the lung, it would there seize upon the mucus and the lung tissue, and would be unable to pass to the blood within.

The great importance at one time attributed to it arose from a belief that the hæmoglobin of the blood-corpuscles had the power of changing oxygen into ozone ; and that by virtue of this action oxidation in the tissues took place. This view has been shown by experiment to be devoid of foundation.

Certain observers, too, found a relationship between the spread of epidemics and the amount of ozone in the air. Thus it was asserted that at the commencement of cholera epidemics ozone was scarce, while towards the close of the epidemic it became abundant. More recent researches have failed to establish any connection whatever between the prevalence of cholera or any other epidemic and the amount of atmospheric ozone.

Probably, however, it may have some influence in destroying noxious substances in the air.

The minute traces of peroxide of hydrogen present in the atmosphere can hardly be supposed to have much importance; though probably not altogether without hygienic influence.

### Ammonia, Nitric Acid, Odours, and Dust

These bodies are present in the air in infinitesimal amounts, and are matters of concern to hygiene rather than to climate. In the open air the amount is never so great as to have any physiological action.

The accidental and occasional constituents of air are not without hygienic importance. Unfortunately our knowledge of these substances is extremely limited.

Under the head of occasional and accidental constituents are included the aromatic vapours perceived in the neighbourhood of forests and of active vegetation generally; the peculiar odour noticeable at the seaside—to a large extent arising from seaweed; also such impurities as sewer-gas and kindred exhalations from decaying matter, and the

various gases and other impurities thrown into the air by factories. In addition to gases, solid particles floating in the air, though not constituting an essential principle of the atmosphere, are, as a matter of fact, never entirely absent.

The influence to be ascribed to odours generally is by no means to be made out from their agreeable or disagreeable character, although probably agreeable odours are in the main healthful, and disagreeable odours prejudicial to health. At any rate the pleasure attendant upon sweet smells gives a stimulus to more vigorous inhalation of the air, and consequently more efficient ventilation of the lungs. Foul odours cause an instinctive tendency to restricted inhalation and lessened pulmonary aeration.

But in all probability the hygienic influence is accidental rather than essential. Unpleasant smells are for the most part to be found where the sanitation is far from perfect, while pleasant odours—apart from artificial perfumery—usually indicate the absence of insanitary conditions in the immediate neighbourhood.

The pleasant odours given out from trees and flowers depend chiefly upon essential or volatile oils, which in conjunction with the oxygenising property of plants do actually aid in destroying noxious elements.

In an interesting research Professor Tyndall showed that odours are endowed with a remarkable power of absorbing radiant heat. Dry air is diathermanous, or, in other words, it allows heat to pass freely through it; but dry air after passing over an odorous substance was found to be altered to an extreme degree in this respect. For example, let the power of dry air to absorb or hinder the transmission of heat be taken as 1, then the absorbing power of the odour of sandal-wood is represented by 32, of lavender by 60, of rosemary by 74, of camomile by 87, of aniseed by 372.

The result of these experiments is the more remarkable when we consider the excessive tenuity of odorous particles. A grain of musk or of ambergris may be kept for years, giving off its characteristic odour in full strength without any appreciable loss of weight. Haller calculated that a

morsel of paper impregnated with less than $\frac{1}{2,600,000,000}$ of a grain of ambergris preserved its perfume during forty years. The amounts actually present in Tyndall's experiments were not, I believe, determined; but in any case were appreciable only to the sense of smell.

If Tyndall's results are trustworthy, the odours of flowers should act like water-vapour in hindering the receipt and loss of heat by radiation; but, so far as I am aware, the point has not yet been confirmed.

It must be borne in mind that the absence of odour is no proof that the air is wholesome. The bacteria that give rise to foul smells are mostly non-pathogenic, the pathogenic germs being all, or nearly all, free from odour. Air laden with the germs of influenza, of small-pox, or of scarlet fever, does not give any warning to the sense of smell.

The connection between dust and disease is almost as uncertain and indefinite as that between smells and ill-health. Some kinds of dust are notoriously injurious: the dust of potteries is especially apt to cause inflammatory changes in the lungs, leading to phthisis. Coal dust, curiously enough, though it may give rise to a somewhat kindred affection, is by no means so likely to do so, and, as a matter of fact, the mortality of coal miners from phthisis is singularly low; while the mortality from the same disease of the Cornish miners, who work in tin and copper mines, is remarkably high. The alkaline dust prevalent through many parts of the United States of America is very irritating to the upper air passages; and to it is ascribed the great frequency of naso-pharyngeal catarrh amongst the inhabitants.

The main practical interest of the considerations just set forth lies in the selection of places of residence. Health resorts do not usually put down in their meteorological tables the variety of smells and of dust provided for visitors; but the physician should never fail to make inquiries in regard to both.

## CHAPTER VIII

### INFLUENCE OF TEMPERATURE ON METABOLISM

Of all the factors of climate, temperature is the most important. This is so for two reasons. Not merely is its action on the organism more direct than that of any other factor, but indirectly it affects the other factors in such a way as to determine their character to a large extent. The moisture of the air, for example, itself an influential factor, is as dependent upon temperature as on supply for its quantity.

The great physiological influence of temperature will be seen when we consider that all the vital processes are concerned directly or indirectly with the production or removal of heat. The mean temperature of the human body remains very nearly the same in the hottest and in the coldest climate; and even in rooms artificially heated and artificially cooled. This constancy of temperature depends upon a complicated mechanism for the regulation of heat in the body; and if the mechanism fails at any point, the consequences are serious. Let us look a little more closely into the matter.

The temperature of the body results from the balance of the income and expenditure of heat. Heat is produced chiefly, though not exclusively, by the oxidation of the tissues.

Of the entire amount of heat produced, the muscles during repose supply 75 per cent, and during contraction 90 per cent.[1] The chemical processes other than oxidation are so slight that they need hardly be brought into consideration: such, for example, as the union of acids with

their bases to form salts. The amount of heat produced varies precisely as the oxidation, independently of the rapidity of the process. As already mentioned, the heat produced by the union of a given amount of oxygen with organic matter is the same whether combustion takes place slowly as in the body, or rapidly as by burning in air. The amount produced has been calculated in various ways: for example, the quantity of heat given off from the body in a certain time has been found by direct experiment; the quantity has been calculated also from the amount that should be developed by the oxidation of the food consumed.

The amount of heat required to raise one gramme of water one degree centigrade is taken as the Unit of Heat, and this is called a "calorie." A kilogramme instead of a gramme is also used as a unit. One kilogramme Calorie (written with a capital C) equals 1000 gramme calories. The kilogramme Calorie is employed in this work.

The amount of heat, or number of Calories, produced in the human body depends upon many circumstances: the age of the person, his health, size, exercise, food, and the external temperature. In a child about 1500 Calories are produced in the course of twenty-four hours; in a grown man leading an active life, about 3000. The average for grown people may be roughly stated as about 2500.

As the temperature of the body remains practically constant, it is evident that this enormous quantity of heat must be given off as it is formed. Were it not so, if the production of heat went on unrestrained, the whole human body would speedily be raised to a temperature above that of boiling water. A simple calculation shows that in such circumstances a person ten stone in weight, and producing 3000 Calories in the twenty-four hours, would require only about thirty-five hours to reach a temperature of 212° F.

The removal of heat, then, is one of the most important functions of the animal economy. It is accomplished in various ways. The following table shows the percentage amount of loss by different channels[2]:—

PERCENTAGE OF HEAT LOST BY DIFFERENT CHANNELS.

| | | | | |
|---|---|---|---|---|
| Skin | 87·5 | Radiation | 73·0 | |
| | | Evaporation | 14·5 | 21·7 |
| Lungs | 10·7 | Evaporation | 7·2 | |
| | | Warming of inspired air | 3·5 | |
| Warming of ingesta | | | 1·8 | |
| | | | 100·0 | |

Where is this heat produced? To know the organs concerned in performing the work will help us to estimate their power of responding to a special call on their activity, of increasing their output when necessary.

At one time it was believed that the lungs were the seat of combustion. Now it is known that whatever heat may be developed by the union of oxygen with hæmoglobin is more than balanced by what is lost in the conversion of carbonic acid and water from the liquid to the gaseous condition; and in fact the blood is cooler on leaving than on entering the lungs. The warmest blood in the body is what has passed through the liver; after the liver comes the brain. The heat produced in these organs is far from accounting for a large proportion even of the entire heat production of the organism. The muscles have been found to be the great oxidisers of the system. It might be supposed that their oxidising or burning activity would be exerted only during functional activity in contraction. This, however, is not so. An ingenious experiment by Claude Bernard shows that a very large proportion of the whole oxidation of the system takes place in the muscles even during a state of repose, though paralysis almost completely destroys their oxidising capacity. Having isolated a vein coming from a muscle he examined the blood procured from it in various circumstances, and compared it with the arterial blood supplied to the muscle. The following table sets forth the percentage of oxygen obtained from 100 volumes of blood before, and from the same quantity of blood after, it has passed through the muscle.

| | | Oxygen. |
|---|---|---|
| Arterial blood of muscle . . . . . . | | 7·31 per cent |
| Venous blood . | Muscle paralysed (nerve cut) | 7·20 ,, |
| | ,, during repose . . | 5·00 ,, |
| | ,, during contraction . | 4·20 ,, |

In what way does the temperature of the surrounding medium modify these processes? A warm-blooded animal, when its temperature is raised ten or twelve degrees, dies speedily, and no such animal can live for any length of time in an atmosphere much warmer than the natural temperature of the blood. When the temperature of the atmosphere is raised what happens? Loss of heat by radiation and by conduction from the surface of the body is diminished. The peripheral blood-vessels dilate, and the sweat-glands become active. In these ways an attempt is made on the part of the organism to facilitate the removal of heat. Corresponding to the peripheral hyperæmia there is anæmia of the internal organs. All the processes of tissue change consequently go on less actively.

Lowering of the temperature of the surrounding medium gives rise to effects the opposite of those just described. Loss of heat takes place rapidly from the skin. The blood-vessels of the surface contract, and internal hyperæmia takes place, accompanied by increased oxidation and consequent increased demand for oxygen, with increased excretion of carbonic acid. The activity of the muscular as well as of the nervous system is stimulated; and a tendency to muscular effort is brought about in order to increase the production of heat.

Practically identical results have been obtained by different observers. Rattray found that the carbonic acid removed by the lungs was upwards of 12 per cent less in the Tropics than in England. Edwards and Letellier found that the elimination of carbonic acid diminished steadily according to temperature in such proportion that if the excretion be taken as 1 at 0° C., it became $\frac{2}{3}$ at 15° or 20°, and $\frac{1}{3}$ at 30° or 40°. An experiment by Edwards may also be mentioned. Sparrows placed in a vessel surrounded by ice in

winter lost only 0·4° C. of heat; while in summer, when exposed to the same conditions, they lost 4° C., exactly ten times as much.

In January, says Vierordt, a man uses 32·2 grammes of oxygen per hour, in July only 31·7 grammes. In animals, with the temperature of the surroundings at 8° C., the $CO_2$ given off was one-third greater than with a temperature of 38° C.

Voit conducted some experiments on men, showing the influence of varying temperatures on tissue change. The food in all cases was identical for sixteen hours before the experiment, and each observation lasted six hours. In these circumstances, and with absolute muscular rest, the carbonic acid exhaled by respiration and the nitrogen excreted in the urine were as shown in the following table:[3]—

| Temperature. | $CO_2$ in grm. | N. in Urine in grammes. |
|---|---|---|
| ° C. | | |
| 4·4 | 210·7 | 4·23 |
| 6·5 | 206·0 | 4·05 |
| 9·0 | 192·0 | 4·20 |
| 14·3 | 155·1 | 3·81 |
| 16·2 | 158·3 | 4·00 |
| 23·7 | 164·8 | 3·40 |
| 24·2 | 166·5 | 3·34 |
| 26·7 | 160·0 | 3·97 |
| 30·0 | 170·6 | ... |

It is seen that the excretion of $CO_2$ decreased as the temperature rose to 14·3° C., and then slowly increased. The combustion of nitrogenous tissue was not greatly affected; but subsequent researches by Rubner[3a] have shown that the combustion of nitrogenous tissue is affected by varying temperatures in the same general way as is the combustion of fats and carbohydrates. Dr. Moursou,[4] by means of comparative observations in the Mediterranean and in the Indian Ocean, arrived at the conclusion that the elimination of urea is less abundant in warm than in temperate regions. Other observers also have noted a

diminution of urea voided by residents in the Tropics even after their return to a temperate zone. In these cases, however, it does not appear certain that the nitrogenous ingesta were controlled closely enough to warrant any inference.

The excretion of urea is increased in febrile ailments. By the earlier observers it was thought to be increased after warm baths. C. F. A. Koch[5] in 1883 found that in animals receiving exactly the same food and not exposed to other disturbing influence than heat there was no increase but rather a diminution in the amount of urea excreted after a warm bath. Simanowsky in 1885, under the direction of Voit and Rubner, confirmed this result. He concluded that in experimental fever the cells and tissues do not cause greater nitrogenous changes than occur in the normal state.

Duke Carl Theodor made an interesting series of observations on a cat.[6] From December 31, 1874, until June 14, 1875, the cat received exactly the same food every day: 120 grammes of meat and 15 grammes of fat. From the beginning of the observation till March 30 the weight of the animal varied between 2557 and 2650 grammes; and from that time on steadily increased up to 3047 grammes. On twenty-two occasions during the six months the tissue change was estimated by Voit's small respiration apparatus in different temperatures. The absorption of oxygen and the removal of $CO_2$ were greater when the surrounding temperature was low.

Colosanti obtained the following results as the mean of twenty-one experiments on guinea-pigs:[7]—

| For 1 kilo Body-weight per hour. | At Mean Temperature of | |
|---|---|---|
| | 3·6° C. | 26·2° C. |
| | cc. | cc. |
| O absorbed . . . . . . | 1856·5 | 1118·5 |
| $CO_2$ excreted . . . . . . | 1554·8 | 1057·4 |
| Respiratory quotient $\frac{CO_2 \text{ excreted}}{\text{O absorbed}}$ | 0·83 | 0·94 |

Page found that in dogs $CO_2$ excretion was lowest at about 25° C.

Pembrey[8] says: "The response to a change in temperature is, in the case of small mammals, almost immediate. Thus, within two minutes of a change from 30° to 18°, a mouse increased its output of carbon dioxide by 74 per cent; within one minute of a change from 33·25° to 17·5° the increase was 60 per cent. The response to an increase of temperature does not take place so quickly; thus within two minutes of a rise from 18° to 34·5° the decrease in the output of carbon dioxide was 18 per cent; within one minute of a rise from 17° to 32°, the decrease was 5 per cent. The power of maintaining a constant mean temperature is readily tested in this manner, as the following example will show (Pembrey):—

"CONSECUTIVE PERIODS OF THIRTY MINUTES.

| $CO_2$ in Decimilligrammes. | External Temperature. | Remarks. |
|---|---|---|
| 1055 | 11·0° | Mouse shivering and active, face and ears pale |
| 957 | 11·0 | Mouse less active, ears pale |
| 518 | 31·5 | Mouse quiet, sweating, ears flushed |
| 262 | 32·5 | Mouse sprawled out, sweating, apparently asleep |
| 815 | 11·0 | Mouse wakes up, becomes very active, ears pale |
| 683 | 11·0 | Mouse quiet, ears pale" |

It is probable that the increased production of heat owing to cold is due not to a direct nervous stimulus, but that it takes place through the intermediary of muscular work. The involuntary contraction of muscles in a shiver or in a rigor augments the production of heat. The lassitude and indisposition for exertion, mental or physical, complained of by Europeans in the Tropics leads to restricted caloric output.

Eijkman[9] in Batavia made some valuable observations on the caloric value of food consumed in the Tropics by Europeans and by native races, and concluded that the amount of heat production and of tissue change was quite independent of external temperature, and was determined solely by the amount of work done. Voit,[10] in a lecture before the Munich Anthropological Society in November 1894, holds that the amount of food required is just as great in warm as in cold climates. While not actually discarding the doctrine that heat production is in part regulated by the temperature of the air, he ascribes a very restricted influence to a purely chemical regulation of heat in response to changes in external temperature. K. E. Ranke,[11] in an admirable monograph on the subject, details the observations he made during the course of an expedition from Munich to tropical South America, and again after his return. He found that the caloric value of the food he consumed and turned to account in the Tropics was nearly one-third less than in Munich before the journey. The diminution fell altogether on the carbohydrates and fats, the amount of nitrogenous food used up in the system remaining practically the same in the Tropics as at home. He further found that when the food was thus diminished the body weight also diminished; while an attempt to keep up the body weight by taking a sufficient quantity of food caused impairment of the general health, slight rise of temperature, and diminished resistance to infectious diseases. On the other hand, the long-continued diminution of food to correspond with the smaller power of getting rid of heat in the Tropics, was also followed by dangerous lowering of nutrition. Hence Ranke considers hot climates dangerous in all cases attended with high heat production; as, for example, physical exertion, excesses in eating, feverish ailments and subsequent convalescence, sudden transition from a cold climate, as in the case of the newly arrived European, and childhood. The infant at the breast, on the contrary, old people, and people that do little work, all having a relatively low heat production, stand hot climates well.

The dark races appear to be endowed with greater facility in getting rid of their heat.

Dr. Ranke also compared his consumption of food in Munich in summer and in winter; and found that the caloric value of the food turned to account in his system in keeping his weight unchanged was nearly the same in winter, when he was exposed to an average temperature of 18° C. (64·4° F.) and in very hot weather in summer. In fact the amount in summer was a little more. During the very hottest days, however, the amount of food necessary to keep the weight constant gave rise to subjective and finally to objective disturbance of health.

Subsequently Dr. Ranke[31] carried out another research soon after arriving at Arosa in winter. The place of observation was 1860 metres above sea-level; and the average temperature to which he was exposed was 10·6° C. (51·08° F.). Clothes and general conditions were practically identical. The result he reached was, that to preserve the body weight at a constant level a very much larger amount of food had to be turned to account in the system than had been the case in Munich. The following table shows the actual quantities of the various kinds of food consumed daily, and the calculated values of the pure or net Calories in the different experiments per square metre of body surface:—

| | Albumen. | Fat. | Carbo-hydrates. | Net Calories per square metre Body-surface. |
|---|---|---|---|---|
| | Grammes. | Grammes. | Grammes. | |
| Munich (winter), aver. temp. 18·0° C. . . | 137·5 | 162·2 | 351·1 | 1504·0 |
| Munich (summer) . | 134·9 | 162·3 | 372·0 | 1529·7 |
| Arosa (winter), aver. temp. 10·6° C. . . | 177·6 | 169·1 | 462·2 | 1808·3 |

The increased consumption of food in the colder weather was not attended by subjective or objective disturbances of health, but on the contrary by a feeling of increased energy and well-being.

These researches and the researches of other observers, especially Rubner, lead to the inference that for man and other warm-blooded animals there is what Dr. Ranke calls a critical temperature. When the surrounding temperature falls below the critical point the production of heat is increased; but when the temperature rises above the critical point the production of heat is not diminished, or a diminution, if it occurs, takes place only at the cost of impaired nutrition generally. The critical temperature, in fact, corresponds with the lowest amount of metabolism, tissue change, or oxidation compatible with the continued steady working of the animal machine in good order. When the temperature is above the critical point the organism defends itself from injury, not by diminishing its output of heat, but by calling into play the means for getting rid of the heat formed. The surface vessels dilate, thus facilitating the removal of heat by radiation and conduction. Perspiration also breaks out, carrying off a large amount of heat by evaporation; but evaporation becomes more and more difficult as the proportion of water-vapour in the air increases.

When the temperature falls below the critical point oxidation becomes more active, and there is also an increased tendency to muscular action, whereby the output of heat is increased. By means of clothes and other artificial devices the limit of resistance to cold is pushed far below the natural limit; but finally a point is reached where man cannot burn up fuel enough to meet the demand for heat.

The critical temperature is placed by Dr. Ranke at from 15 to 20° C. (59 to 68° F.). This also is considered by him to be the optimum of temperature for man, securing the well-being of the organism with least expenditure of energy on its part. A lower temperature requires more active tissue change; a higher temperature requires special measures to get rid of the heat produced in active life.

Rubner has examined the question experimentally. He arrived at the following mean values for the number of Calories produced per kilogramme in twenty-four hours at various temperatures by a small dog [32] :—

| Temperature. | Calories per Kilogramme. |
|---|---|
| °C. | |
| 7·6 | 86·4 |
| 15·0 | 63·0 |
| 20·0 | 55·9 |
| 25·0 | 54·2 |
| 30·0 | 56·2 |
| 35·0 | 68·5 |

This dog, which weighed 4 kilogrammes, was long-haired, and the experiments were made during fasting. As Rubner shows by a great number of other experiments, the results are considerably modified by the size of the dog, by the length of his hair, and by food. The following table [33] compares the Calories produced by the same dog at different temperatures with his normal hair-covering and when closely shorn:—

| Temperature. | Calories per Kilogramme in 24 hours. | |
|---|---|---|
| | Normal Hair-Covering. | Closely shorn. |
| °C. | | |
| 20 | 55·9 | 82·3 |
| 25 | 54·2 | 61·2 |
| 30 | 56·2 | 52·0 |

From his careful and extensive researches concerning heat-regulation in fasting animals, Rubner infers that [34]—

1. At low and medium temperatures animals make use of chemical regulation (altered heat production).
2. At higher temperatures physical regulation of temperature (altered heat emission) comes into play.
3. At very high temperatures the body heat and the heat production are arrested. The animal gets into a state of hyperthermia.

In accordance with these views is the fact noted by several observers that a person while going from a cold or

temperate climate to the Tropics, and during residence in the Tropics, or at least for a time, usually has a temperature somewhat higher than the normal in the temperate zone. As to whether this greater body-heat is temporary or permanent, some difference of opinion exists. The most extensive series of observations has been furnished by Dr. A. Crombie of Calcutta. Dr. Birch[35] gives the results as follows:—

| | Mean A.M. Temperature. | Mean P.M. Temperature. | Mean Temperature. | Max. Daily Range. |
|---|---|---|---|---|
| | ° | ° | ° | |
| English Averages | 97·763 | 98·341 | 98·084 | 1·41 |
| Crombie's Indian Averages . | 98·21 | 98·77 | 98·49 | 1·31 |

These figures refer to mouth temperatures. Dr. Birch continues: "These figures show that the body temperature of the European living in Bengal is about 0·41° F. higher than the average of healthy persons in England; and they confirm Rattray's observations in the Tropics and England, as well as the law laid down by Becher, that the body-heat increases in the proportion of 0·05 for every 1° F. of the air. Similarly, according to Wunderlich, Brown-Séquard, on a journey from Mauritius to France, found that eight healthy people, when the external temperature was 46·4° F., had a mean temperature under the tongue of 97·9° F.; but a week later, when the air had risen to 77° F., the body-heat was 99·4° F."

Crombie's observations were made on persons who had been for some time resident in the country. The European newly arrived in the Tropics exhibits a somewhat higher temperature.

The daily fluctuations of the temperature of the European in Bengal do not differ from the English average, except that the curve for temperate climates is about half a degree lower. In Bengal, Crombie, as quoted by Birch, found them as follows:—

| | °F. |
|---|---|
| From 2 A.M. to 7 A.M. = . . . | 97·83 |
| „ 8 „ 1 P.M. . . . | 98·61 |
| „ 2 P.M. to 8 „ . . . | 98·92 |
| „ 9 „ 1 A.M. . . . | 98·54 |

Exercise appears to cause a quicker, greater, and more lasting rise of temperature in the Tropics than in temperate climates.

Plehn [36] made many careful observations on himself and others during two journeys to Dutch India and Japan, and again on the Cameroon Coast. In the Red Sea, when the temperature of the air lay between 28·9° and 31·8° C. (84·02° and 89·24° F.), and the relative humidity ranged from 60 to 74 per cent, Plehn found his axilla temperature nearly one degree centigrade higher than in the temperate regions in winter with an air temperature from – 2·8 to 7·8° C., and relative humidity from 88 to 73 per cent. Ordinarily, however, the difference was seldom more than half a degree centigrade; and this—half a degree centigrade—also was the excess of his temperature over the normal, on the Cameroon Coast before acclimatisation. When Plehn became acclimatised, his temperature was the same as in the temperate regions.

Another fact concerning the influence of temperature on food and nutrition is cited by Armsby [37] from Shelton. At the Kansas Agricultural College, Shelton "found that swine kept in an open yard during rather severe weather required 25 per cent more corn to make a given gain, than those sheltered from extreme cold."

Amongst frequently observed clinical facts bearing on the subject, one or two may be mentioned. Persons coming from the mild climate of England to the cold climate of Davos in winter frequently lose weight at first. Those who gain weight from the beginning take much more food than at home. Persons going down from Davos, in spring, to the warmer lowlands commonly put on weight.

Persons suffering from tuberculosis with slight tendency to pyrexia usually show in their temperature charts the

influence of a spell of warm weather occurring during the cold season. This happens, for example, when the Föhn wind blows at Davos during the winter. The same influence is frequently seen as the effect of exposure to the full blaze of the sun during the winter at Davos. Rubner calculates that the effect of the direct rays of the sun may be taken as half the sun temperature added to the temperature of the air in the shade. For example, if the air in the shade is 2° C. and the black-bulb thermometer in the sun is 50° C.,—a sort of combination not infrequent in Davos,—the result is the equivalent of a shade temperature of 27° C. (80·6° F.).

The difficulty in getting rid of the heat produced is, no doubt, one reason why patients with a feverish tendency do badly in hot weather and in hot climates.

In the Tropics great heat is not infrequently accompanied by high relative humidity of the air. When this is the case, the loss of heat from the body is still further diminished, evaporation being restrained where the atmosphere already contains much moisture.

These influences of increased heat and of increased cold hold good only within certain limits. Heat above a certain point, and cold below a certain point, alike bring about the death of the tissues. These points differ for different species, and also more or less for individuals of the same species. M. Berger remained with little discomfort for seven minutes in an oven heated to a temperature of about 186° F., while a temperature under 130° became insupportable to M. Delaroche and made him ill. The importance of custom or acclimatisation in regulating these processes cannot be over-estimated.

The point may be further illustrated from the lower forms of animal and vegetable life. By this means we shall better understand how temperature affects more highly organised beings. Bacteria and other proto-organisms have certain limits of heat within which only they increase and multiply. Their activity is greatest a little before the upper limit is reached. The microbe of charbon, for example, is active only between the temperatures of 16° C. and 44° C.

Its greatest activity is at a temperature of about 30°, while at 41° it begins to exhibit signs of lethargy. Davaine has shown that the number of these organisms required to produce the symptoms of the disease to which their presence gives rise is for a given animal 2000 times greater in winter than in summer. The same author has shown that a quantity of septic blood which when injected will kill a cobra in summer, is without effect in winter: from $\frac{1}{50}$ to $\frac{1}{500}$ of a drop is fatal in summer; while in winter from $\frac{1}{10}$ to $\frac{1}{50}$ of a drop is required. The microbe of charbon perishes at a temperature of 44° or 45° C. As Pasteur has pointed out, this fact explains the immunity of birds from charbon, their temperature normally being rarely under 42° C. If the temperature of the bird be artificially lowered the immunity disappears. Another important fact in reference to the action of temperature on micro-organisms is that above and below the temperature of greatest activity there is in some instances a change in form. Thus below 16° C. and above 44° C. the micro-organism of charbon becomes large in size and pyriform in shape. The manner of reproduction, moreover, is altered: sporulation, a relatively high form of generation, is replaced by scission, a relatively low form.

The action of temperature on more highly organised beings is quite as remarkable. Grains of *Sinapis nigra* kept in a medium at 0° C. germinated in 17 days; at 2° C. they germinated in 16 days; at 3° C. in 9 days; at 5° C. in 4 days; at 9° C. in 3 days; and at 12° C. in $1\frac{3}{4}$ days. It would seem, says Bordier,[12] from whom I take these facts, as if for a given species the same amount of vegetation requires the same amount of heat. According as, owing to latitude and altitude, this total amount of heat is distributed over three months or over one month, the same result takes place in the longer or shorter period. In the instances just noted a temperature of 12° is the most favourable, and a greater heat proves noxious. Thus at 17°, instead of germinating in $1\frac{3}{4}$ days, the seed germinates in 3 days. At 28° only one-third of the seeds germinate, and at 40° they no longer germinate at all. The estimation of the heat necessary

to the growth of plants is, however, by no means so simple. It is discussed in Kerner and Oliver's *Natural History of Plants*, 1902, vol. i. p. 557 and ff.

To the human organism those atmospheric conditions are most stimulating in which tissue change is at its highest. High tissue change is a result, other things being equal, not of temperature alone but of all those circumstances that help in removing heat from the body. These circumstances and the application of the foregoing facts will come more and more into view as we proceed.

Only one or two further points need be considered here.

Heat and cold in alternation have a very much more marked effect than has either when continued for some time without change. A given amount of cold following heat has a much more stimulating action than has the same amount of cold long continued, and in like manner heat following cold brings about greater lassitude or stimulation according to the individual reaction than does long-continued heat.

### Influence of Temperature on the Digestive Organs

That hyperæmia of the abdominal organs is usually present both in the native races and in Europeans in the Tropics seems to be established by the evidence obtained at operations and post-mortem examinations. This condition predisposes to pathological processes. Diarrhœa occurs readily either from changes in the weather or from errors in diet. Dysentery and liver ailments are amongst the commonest of tropical diseases. The tendency to these maladies is no doubt increased by unsuitable food, or by a mode of life out of harmony with the climate; but the abdominal plethora must be looked on as one of the favouring conditions.

Cold has a stimulating effect on the digestive system —always provided that the cold be not excessive. It is a subject of common observation that appetite and digestion are better in winter than in summer; and explorers who have travelled in the Arctic zone tell us of the

enormous quantities of food served out as the party enters the colder regions.

Excessive cold lowers the activity of digestion as of all other functions. Different people vary enormously in regard to the amount of cold they can withstand. Certain it is that the same degree of cold which serves in most people to whet the appetite and improve digestion, causes symptoms of indigestion in others. Many cases have come under my observation where the severe cold of an Alpine winter gives rise to dyspepsia, which does not pass off until the warmer weather of spring appears.

The increased removal of heat from the body in cold weather requires the assimilation of a greater amount of food to replace the loss. If the digestive system fails to respond to the increased demand, the general nutrition is lowered; and with the lowering of the general nutrition the digestive system itself suffers in turn, so that speedily the vitality becomes distinctly impaired.

This point is one of the most fundamental to be borne in mind by all who are concerned with the selection of climate. In no disease will improvement take place if the general vitality is lowered, while in most cases some advantage is likely to arise from an improved state of nutrition.

### Influence of Temperature on the Muscular and Nervous Systems

As the muscles are merely the end organs of the motor nerves, these two systems will be most conveniently considered together.

The depressing influence of heat on the nervous system is universally recognised. Warm climates are spoken of as enervating and relaxing; cold climates as stimulating and bracing. In the temperate zone there is, as a rule, a marked diminution of energy during the heat of summer, and an increase of energy during the winter. The warm time of day is also the time of indolence and rest in all countries where the heat tends to be oppressive. In the south of

Europe and in the Tropics a mid-day siesta is an established habit of the people.

Excessive cold, like excessive heat, lowers the nervous energy and diminishes muscular activity. While heat-stroke is the cause of many deaths in the Tropics, excessive cold is responsible for hardly fewer fatalities in the colder regions. In Russia, for example, Tourdes [13] states that according to official documents about 700 persons yearly perish from the immediate effects of cold.

The manner in which great heat destroys life is well known through the experience of our medical officers in India and elsewhere in the Tropics, to say nothing of the cases of sunstroke that occur every summer even in the temperate zone.

Various theories have been put forward to account for death by sunstroke. That the evil result is not due to changes in the muscular system, especially in the heart muscle, or to changes in the blood, as at one time was thought, is shown by the fact that both muscle and blood are unaltered by a temperature that proves fatal to the organism as a whole. Goldscheider and Flateau [14] in 1897 showed that animals whose temperature did not exceed 41·5° C. did not present any appreciable changes in the nervous system. When the temperature, however, exceeded 43° C. numerous lesions were found throughout the whole length of the spinal cord, especially in the axis-cylinder. But these changes were evidently secondary, not directly due to the heat, as they did not occur in decapitated animals exposed to the same temperature.

The most probable explanation of the symptoms and results of sunstroke lies in the formation of toxins under the influence of heat. Vincent in 1887 studied the toxicity of the blood and tissues of animals that had been exposed to overheating. He found that the transfusion of blood of an overheated animal, or the injection of an aqueous extract of its organs, especially of the central nervous system, speedily caused death with the symptoms of heat-stroke. In the hands of Laveran and Regnard, however,

the transfusion of blood did not yield the same results. Possibly the toxins in question are very unstable.

An ingenious speculation by Sambon [15] ascribes sunstroke or "siriasis" to a specific organism. Heat, whether it acts directly or indirectly, appears in any case to be an essential condition of the attack.

The effect of excessive cold is in England by no means so familiar as is the effect of excessive heat. Death from cold may occur in various ways—sometimes suddenly, but more usually it occurs gradually, and the chief symptom is an overpowering sense of drowsiness. Thus soldiers on a march when overcome with cold drop out of the ranks, and, sitting down, say they will rest a few moments. Those few moments are their last. Unconsciousness comes on speedily, and the end is without suffering. The story of Solander, a celebrated naturalist of the eighteenth century, is well known. Returning from a mountain excursion in Terra del Fuego, his party was suddenly overtaken by intense cold. Solander warned his companions against yielding to the sense of drowsiness. "Whoever sits down sleeps; whoever sleeps will never wake again," he said. A little later Solander himself wished to sit down and rest, and was with difficulty led along by his friends. Two of his followers yielded to the desire, and perished.

Some experiments by Laveran [16] show that cold coagulates the myelin surrounding the axis-cylinder, but does not affect the axis-cylinder itself or the neurilemma. If reaction occurs, inflammatory changes may lead to entire loss of nerve function (neuritis and perineuritis).

Recovery may take place even when the general temperature has been very greatly lowered. "A woman drunk and frozen, with a vaginal temperature of 78° F., is known to have recovered; a drunken man exposed during the night at a temperature of 33° F. has been known to survive, although the rectal temperature was down to 75° F." [17] These cases, if true, are all the more remarkable from the established fact that alcoholic excess greatly diminishes the resistance to cold.

On muscle, cold has a stiffening effect; and experiment has shown that under its influence contraction becomes less rapid, but lasts longer in response to electric stimulation. The stiffening of the muscles and consequent loss of delicate movement is familiar to every one who has had very cold hands. Moderate warmth (30° to 35° C.), on the contrary, increases the rapidity and amplitude of muscular contraction.

A moderate degree of cold is universally recognised as stimulant and bracing. The more northern nations of the temperate zone are commonly held up in contrast with the nations of the South. The greater energy and endurance of the Northerner are compared with the vivacity and lack of perseverance of the Southerner. Race no doubt accounts for much of the difference in character, but is hardly sufficient to explain it entirely. Ratzel [18] points out that such differences are found to exist in races essentially the same. The North Germans, for example, differ from the South Germans; the Northern Russians from the Southern; the Northern Chinese from the Chinese of the South; and in each case the difference is of the same kind. The North Italian differs also in like manner from the South Italian; the North Frenchman from the Provençal, and the Spaniard of the North from his countryman of the South.

In the instances cited by Ratzel it can hardly be admitted that the difference in character is altogether due to climate, and that race is devoid of influence as a factor. The successive invasions of the southern countries by the northern nations, and the intermingling due to commerce and other causes, must have led to some blending of adjacent people. Though the whole of Spain and the whole of Italy were actually overrun by northern tribes, the southern portions of both these countries were only to a small extent subjected to the influence of the invader.

Another reason has been offered for the sturdy character of the Northman, for his energy, his perseverance, and his reserve in contrast with the light, careless, cheerful disposition of the Southerner. The physical conditions of life are much easier in the South than in the North. The

greater luxuriance of vegetation, the smaller amount of food on which existence can be comfortably maintained, the absence of any great necessity for good clothing and sound dwellings as a protection against rigour of climate—all these circumstances predispose to gaiety and indolence. As Draper remarks, "The Northerner is obliged to do to-day what the Southerner can put off till to-morrow."

Another circumstance has been pointed out by Ratzel, which to some extent also diminishes the claim of climate to influence character. Settlers in a new country select when possible a place where the climate most nearly corresponds to what they have been accustomed to. The Scandinavian immigrants to America have settled chiefly in the northern states—in Minnesota and Dakota, for example; while the Latin races are found most largely in the southern states; the Germans occupying chiefly the mid-portion.

There is a certain range of temperature in which nervous and muscular energy are at their highest. This range of temperature differs very much for different people, and even for the same person it differs much at different times according to circumstances. Ross tells that when he and his party had for a time been exposed to a temperature of $-47°$ F., a temperature between $-29°$ and $-25°$ F. was found agreeable; and Captain Parry records that when his men had for some time been exposed to a temperature of $-13°$ F., they complained of the heat when the thermometer rose to $26°$ F.

The fact just mentioned illustrates, too, one important difference between excessive cold and excessive heat. Almost any degree of cold can be successfully resisted by means of suitable clothing, food, and exercise. Against excessive heat, on the contrary, our means of protection are few and imperfect. Punkahs, thermantidotes, and other devices in use in tropical climates for lowering the temperature have but a limited sphere of action, and do not altogether succeed in nullifying the evil effects of the heat.

During the prevalence of excessive heat a high degree of nervous or muscular activity is attended with risk. Functional activity of the nerves and of the muscles alike causes

development of heat; and, as there is difficulty in the circumstances in removing the heat produced even when organic combustion is at its lowest, such an increase of heat may convert the difficulty into an impossibility. This fact is now so well recognised that during a spell of excessive heat, work in the army and in Government factories, unless absolutely indispensable, is commonly stopped or postponed till the cooler hours of the day.

Moderate exercise, however, and moderate mental work, without needless exposure to heat, have a beneficial influence on the general health, and in this way diminish the liability to heat apoplexy.

### Influence of Temperature on Respiration

The functional activity of respiration is decreased by a high temperature of the surrounding air—that is to say, the exchange of gases—the absorption of oxygen, and the removal of carbonic acid—becomes less. It might, therefore, be reasonably expected that respiratory movement would be less frequent and less profound. Strange to say, the influence of heat and of cold respectively on the frequency of respiration has not yet been definitely established. The older view was that the respiration rate was augmented by heat and diminished by cold. Rattray [19] contested this statement, and, on the basis of observations made during the course of voyages between England, Bahia, and the Cape of Good Hope, laid it down as a rule that respiration becomes less frequent by one or two movements a minute as one passes from the temperate zone to the Tropics. More recently some French observers, Crevaux, Féris, and Jousset,[30] have brought forward a large number of facts to substantiate the older view. These observers found that respiration became more frequent by two or three movements in travelling from France to the Tropics. Plehn,[24] in moving rapidly from a cold to a hot climate, noticed a very slight increase in the respiratory rate, which disappeared after acclimatisation.

As both Rattray and his opponents seem all to have observed their cases with care, we are not justified in ascribing the discrepancy to mal-observation. We know that the number of respirations in the same individual varies according to a variety of circumstances—age, the waking or the sleeping state, emotion, exercise, or digestive troubles, such as flatulence. Moreover, one person might regard as agreeable a degree of heat that would be oppressive to another. The vital capacity, too, in different persons would naturally influence the result.

Air is rarefied by heat to a greater extent than might be supposed. When much water-vapour is present, the quantity of air in a given volume is still further lessened in a remarkable degree. At a temperature of 30° C. a given volume of dry air weighs about $\frac{1}{10}$ less than at freezing-point; while a given volume of fully saturated air at 30° C. contains about $\frac{1}{8}$ less of air by weight than the same volume of saturated air at freezing-point.

From considerations of this kind it has sometimes been inferred that the diminished supply of oxygen in heated air is the cause of the diminished oxidation in the system. Experiment, however, has shown that the amount of oxygen used depends not on the supply, but on the demands of the organism. In ordinary circumstances the supply is much more abundant than is really needful; so that a moderate diminution in the amount makes practically no difference; and if the demand of the system becomes less at the same time, the breathing may become shallower and less frequent. Even a considerable diminution of oxygen in the air can, if necessary, be balanced by deeper and more rapid respiration.

With increased rapidity of breathing the quantity of water removed by the lungs can be greatly augmented. Whether the organism has recourse to this refrigerating mechanism depends on the sufficiency of the ordinary means of getting rid of heat, and would vary from person to person.

The spirometric or vital capacity is, as a rule, increased

when a person goes from a temperate to a tropical climate. On this all observers agree. Jousset, however, holds that the increase is temporary. After a period varying from one to three or even twelve months the vital capacity, he found, sank to a point below its original amount. The increase in the first instance ranged, as a rule, from 200 to 300 c.cm. (12 to 18 cubic inches), though in some instances the increase was more, and occasionally no increase was observable.

The augmented vital capacity was ascribed by Rattray to the diminished amount of blood found in the lungs in the Tropics—a fact observed by Dr. Francis of Bengal. The average weight of the lungs was found by Dr. Parkes [23] and others to be less than in Europe. The smaller amount of blood in the lungs was in turn accounted for by the well-known greater vascularity of the surface.

The explanation would be sufficient for Rattray, who believed the spirometric increase to be permanent; but by no means makes clear the changes recorded by Jousset.

Cold, we have already seen, increases the activity of the respiratory function: that is, it causes a greater amount of oxygen to be absorbed, and of carbonic acid to be given off. It is generally said to make respiration deeper and slower. Peyer noted this effect on the members of his party in the Polar expedition of 1872-4. If the reflections in the foregoing paragraphs are well founded, we might, however, expect that the response would not always be the same with different individuals. Moreover, it is known from independent observation, that cold of a certain degree of intensity lowers the activity of respiration in common with all other vital processes.

### Influence of Temperature on the Circulatory System

The influence of heat and of cold on the circulation is much the same as on respiration. Here too we have the same discrepancy between Rattray and other observers. According to Rattray the pulse is slowed by about two and a half beats

as one passes from the temperate zone to the Tropics; Jousset, Crevaux, and Féris, on the contrary, bring forward a great number of observations to show that an increase of about ten beats takes place in the same circumstances. The figures on which Jousset based his deductions are given with considerable fulness. While they warrant the statement that in the individual cases under observation quickening of the pulse was the most usual result, the exceptions show that the reaction to heat differs in different persons. Plehn [25] found, as a rule, greater frequency of pulse on the passage to the Tropics and during the early part of residence there. After acclimatisation the pulse fell to its normal rate.

Greater frequency of the pulse might be expected from the fact that the peripheral vessels of the surface undergo dilatation. The increased volume of the peripheral vessels naturally diminishes the tension throughout the arterial system, and, according to Marey's law, lower tension is accompanied by a quicker pulse.

According to Jousset, besides lowering of tension an increase of elasticity is observable in the arteries, as evidenced by marked dicrotism in the sphygmographic tracing. Plehn [26] also observed lower arterial tension in the Tropics, which did not pass off with prolonged residence.

In cold climates the pulse is usually stated to be slower and the tension higher. Galen said "in hieme pulsus duriores et paulo vehementiores, tardiores fiunt." This is what might be expected from the contraction of the surface vessels. Observations bearing on the point are not so numerous here as in the case of hot climates. In all probability the same difference would be observed in the reaction of different individuals to cold in the Arctic regions as in the case of heat in the tropical zone. Laveran [20] quotes Blumenbach as saying that the Greenlanders have a pulse rate of between thirty and forty beats to the minute. A higher pulse rate is usually recorded of negroes and other inhabitants of tropical countries than is usual amongst Europeans. A table given by Topinard shows that no general statement of this kind can be made.

The blood was formerly said to be less rich in red corpuscles in the Tropics than in cold climates. Pedro de Megalhaes [21] found at Rio Janeiro that the number of red corpuscles in 1 cmm. varied as a rule from 2,400,000 to 2,800,000. Only rarely was the proportion so great as 4,000,000.

However, according to the researches of Glogner,[28] Eijkman,[29] Plehn,[27] and others, the number of the red blood corpuscles and the amount of the hæmoglobin remain unchanged in the European in the Tropics, and are the same as in the native races. Marestang found an increase of red blood corpuscles in sailors in the Tropics. Anæmia, when it occurs, is probably due to malaria or bad hygienic conditions.

In cold climates, on the contrary, the blood used to be regarded as being rich in corpuscles; and Lombard speaks of the hyperæmia of the Polar regions. The Greenlanders are commonly stated to suffer much from plethora. Their exclusively animal diet has, however, probably much to do with the corpuscular richness of their blood. It should not be forgotten that pernicious anæmia also occurs in the North. But probably cold has only a very indirect share in its causation.

In hot climates palpitation and dilatation of the heart are common, and are usually ascribed to anæmia.

### Influence of Temperature on the Skin

The functional activity of the skin is greatly heightened in the Tropics. Almost all Europeans complain that the body is constantly bathed in perspiration. This is especially the case where the air is moist as well as hot. When the air is relatively dry such perspiration is rarely troublesome. Rattray has calculated that the secretion of sweat is increased by 24 per cent. Not merely is the perspiration proper increased, but also the secretion from the sebaceous glands. By means of this abundant secretion the danger of heat-stroke is greatly diminished. The evaporation of the water

from the surface of the body carries off a large amount of heat; and at the same time the droplets of water on the surface reflect the heat and do not allow it to attack the skin.

Cold constringes the surface vessels, lowering at the same time the activity of the skin and its nutrition. In great cold the skin readily cracks, and wounds heal slowly. Chilblains, from which many people suffer in winter, are one manifestation of lowered vitality, brought about by the less vigorous circulation.

Where there is a tendency to perspiration a cold climate is of value in giving tone to the nerves and vessels of the skin. As chills occur very frequently in connection with abundant perspiration, steady cold has a further indirect effect in diminishing the frequency of internal congestion.

### Influence of Temperature on the Urinary System

With the increase of heat and the freer action of the skin the flow of water from the kidneys becomes lessened. We have already seen that the quantity of urea excreted is somewhat less; and a like diminution probably takes place in most of the other solids. Rattray's observations do not show a strict relationship between temperature and the solids excreted; but the conditions in which his observations were made are hardly such as to warrant any very definite conclusion. When the quantity of water drunk remains the same the urine is more concentrated, and has a higher specific gravity. When fluid is taken freely, the quantity of urine may remain the same as in a colder climate.

According to Dundas, a kind of atrophy of the kidney is seen amongst residents in the Tropics. This atrophy is due seemingly to functional inactivity of the organ. The diminution in the excretion of urea is said to persist after leaving the Tropics. Bouchardat[22] speaks of men in good health who, on returning to Paris from Java, Cuba, or Rio Janeiro, voided only from 17 to 22 grammes of urea in the twenty-four hours, whilst, in the same city, inhabitants of

Copenhagen, of Stockholm, and of St. Petersburg produced from 38 to 42 grammes in the same time. The urine of the returned tropical habitués often abounds in uric acid and urates (cf. p. 71). In the absence of exact records of the amount of nitrogenous food ingested these results have comparatively little value. A marked increase in the quantity of urine is generally observed when the weather becomes cold, or when one passes from the temperate to the Arctic regions.

## Influence of Temperature on the Genetic System

A great deal of importance has been attributed to the action of heat on the genetic functions. It is generally said that a much greater degree of activity is brought about in hot climates. This observation seems to be well founded. All writers are agreed that venereal excess is much more disastrous in its consequences in hot than in colder climates.

By comparative observation it has been established that the function of menstruation begins much earlier in hot climates than in cold, the average age at which it appears in the Tropics being about thirteen or fourteen years, while in the Arctic regions it rarely appears before the eighteenth year. The children of English parents born and brought up in India menstruate on an average nearly a year earlier than in England.

The menopause in Europeans in tropical climates occurs earlier, and is apt to be attended with more copious hæmorrhages and with more disturbance generally than in the temperate zone.

Childbearing is said to cause a good deal of debility in European women in hot countries.

When English girls who have recently begun to menstruate come from England into the cold of an Alpine winter, menstruation not uncommonly ceases, until the return to a warmer climate.

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# CHAPTER IX

## INFLUENCE ACTION OF ATMOSPHERIC HUMIDITY

### General Considerations

The physiological action of the water-vapour in the air is almost entirely of an indirect character. Atmospheric humidity modifies the other meteorological elements—the temperature of the air, the amount of light, the electrical conditions, and, to some slight extent, the barometric pressure. Water-vapour, besides modifying the surrounding temperature, greatly influences the heat-removing properties of the air; and in this way its presence in the long run has great significance.

While humidity moderates the temperature of the air, it intensifies the chilling action of cold and the oppressive influence of heat. Dry air a little above the freezing-point of water is not felt to be nearly so cold as moist air of the same temperature; while warm air if dry is pleasant, but if saturated with moisture, oppressive and enervating.

What is the secret of this seeming anomaly? Dry air is a poor conductor of heat, but it does not materially hinder radiation. Water-vapour, on the contrary, is a relatively good conductor of heat, but it hinders radiation. Now the body gets rid of its heat by radiation, by conduction, by convection, and by evaporation. In dry still air heat is lost mostly by radiation and evaporation—radiation being most active when the air is cold, evaporation being most active when the air is warm. Convection comes into play only when the air is in motion, and it is then a very

potent factor indeed; while conduction is fully operative only when the air is moist. Moisture, while hindering both evaporation and radiation, greatly increases the action of convection.

It will thus be seen that a change in the amount of moisture present in the air causes an entire change in the activity of the heat-removing organs. Suppose, for example, the air to be dry and moderately warm, the skin will then be actively employed in removing heat by radiation and in supplying water for evaporation. If, however, the air becomes charged with vapour of the same temperature, both radiation and evaporation are at once hindered and the body has difficulty in getting rid of heat as it is developed. By virtue of the automatic heat-regulating mechanism of the organism, the development of heat is then reduced. In other words, there is indisposition to muscular or nervous action; and lassitude and lack of energy are felt.

Commonly, however, air when it becomes moist falls somewhat in temperature. Heat continues to be removed quite freely from the body, but now the mode of action is by conduction instead of by radiation and evaporation as in dry air. The difference is more important than would at first sight appear. So long as the air is dry, the heat removed by radiation and evaporation corresponds to the needs of the organism. If the air becomes colder radiation and evaporation diminish in amount, the surface vessels contracting and less heat demanding removal. The skin itself becomes cold, but it acts as an efficient protection to the organs within. When warm moist air is cooled even a little, though radiation and evaporation act less vigorously, conduction comes into play. Heat is steadily removed, while the degree of cold may be insufficient to cause either the surface constriction which would protect the inner organs, or such a response on the part of the organism generally as would lead to a more rapid development of heat. Thus there is the liability to chill; and a sense of chilliness is complained of in warm, moist climates when the temperature falls two or three degrees.

Should heat, however, in response to the stimulus be developed in great abundance, it can only with difficulty be removed, conduction alone being inadequate to replace radiation and evaporation. Thus warm moist climates receive such epithets as "muggy," "oppressive," and "enervating." The important difference then between the removal of heat by dry cold and by moist cold is this: in dry cold the removal of heat is determined by the needs of the body; in damp cold there is a positive leakage of the heat store; yet when heat is produced beyond a certain rate there is difficulty in getting rid of it. The presence of wind intensifies the action of cold and especially of moist cold.

Clothing, which forms an effective obstacle to loss of heat by radiation, serves its purpose to but a small extent in a damp atmosphere, the clothes themselves becoming saturated with moisture and thus converted into good conductors.

When the air is cold it will hold but a very small quantity of water-vapour, so that when the temperature is below freezing-point the conducting qualities of the vapour may practically be left out of account even when the air is saturated with moisture. But when saturation of the air occurs and the vapour becomes precipitated in the form of cloud, mist, or fog, radiation is hindered and evaporation also to some extent. Then if heat be largely developed by muscular exercise, it cannot readily be dispersed, a sensation of oppression is felt, and the air is said to be "muggy." The "mugginess" due to humidity is removed by wind, especially at a low temperature.

In a cold climate, therefore, the absolute humidity is without importance; and the relative humidity of importance only when the saturation point is reached. In a warm climate the relative humidity is the main point to consider, and the absolute humidity is usually great enough to render conduction comparatively good.

Rubner[1] has studied experimentally the influence of moisture on tissue change. Its influence varies according

to the temperature of the air and other circumstances, and does not admit of a concise general statement.

## Influence of Humidity on the Skin, Kidneys, Circulation, and Respiration

On the circulation and on the skin also certain indirect effects of humidity are to be noted. A damp atmosphere tends to cause moisture of the skin through lessening evaporation. Thus, during active exercise the surface is apt to be hot and bathed in perspiration, and to become cold and clammy when the special production of heat is discontinued. A not infrequent result of this condition is "rheumatism" in various forms.

The relative proportions of water removed by the skin, by the lungs, and by the kidneys respectively, are determined by several factors, amongst which atmospheric humidity holds an important place. The following table from Renk[2] shows the results of observations made by Pettenkofer and Voit, in regard to food and work:—

Excretion of Water from the Body.

| | Total. | By the Excreta. | By Respiration and Perspiration. | |
|---|---|---|---|---|
| | Grammes. | Grammes. | Grammes. | Per cent. |
| Subject I. (man)— | | | | |
| During fasting and rest . . | 1977 | 1148 | 829 | 42 |
| „ „ „ . . | 1677 | 863 | 814 | 49 |
| „ „ work . . | 2525 | 746 | 1779 | 70 |
| „ medium diet and rest . | 2390 | 1562 | 828 | 35 |
| „ „ „ „ . | 2187 | 1178 | 1009 | 46 |
| „ „ „ „ . | 2387 | 1430 | 957 | 40 |
| „ „ „ work . | 3220 | 1177 | 2043 | 63 |
| „ „ „ „ . | 2700 | 1288 | 1412 | 52 |
| „ albuminous diet and rest | 3118 | 2008 | 1110 | 35 |
| „ „ „ „ | 3622 | 2414 | 1208 | 33 |
| „ non-nitrogenous „ | 1835 | 910 | 925 | 50 |
| Subject II. (man)— | | | | |
| During medium diet and rest . | 2014 | 1111 | 903 | 45 |

The result, however, will naturally be greatly modified by other influences, such as the temperature of the air, the amount of liquid ingested, and the tonicity of the nerves and vessels. In ordinary circumstances the loss of water from the skin in a grown man is probably seldom less than from 500 to 700 grammes in the twenty-four hours.

The amount of water carried off through the lungs is mainly dependent upon the temperature of the air and its relative humidity. Another valuable table from Renk[3] exhibits Krieger's observations on the subject.

The amount of air breathed in the twenty-four hours is taken as 9000 litres (on the assumption that 500 cc. are inhaled in each respiration, and that 12·5 respirations occur in the minute). A further assumption—not strictly true—is that the expired air is saturated with moisture :—

Quantity of Water-Vapour removed by the Lungs in Twenty-four Hours (in 9000 litres of air).

| Temperature of the Air. | | Relative Humidity of the Inspired Air. | | | | |
|---|---|---|---|---|---|---|
| Before Inspiration. | After Expiration. | 0 Per cent. | 25 Per cent. | 50 Per cent. | 75 Per cent. | 100 Per cent. |
| ° C. | ° C. | Grammes. | Grammes. | Grammes. | Grammes. | Grammes. |
| − 10 | + 30 | 271 | 266 | 261 | 256 | 250 |
| 0 | 32·7 | 313 | 302 | 291 | 280 | 269 |
| + 5 | 33·9 | 333 | 318 | 303 | 288 | 273 |
| 10 | 35·0 | 354 | 333 | 312 | 290 | 269 |
| 15 | 36·0 | 373 | 344 | 315 | 286 | 258 |
| 20 | 36·9 | 390 | 352 | 313 | 274 | 236 |
| 25 | 37·2 | 396 | 345 | 293 | 242 | 191 |
| 30 | 37·5 | 400 | 335 | 267 | 199 | 131 |

Examination of the foregoing table will show that at low temperatures (freezing-point and under) the relative humidity of the atmosphere but slightly influences the quantity of water carried off from the lungs; while at the higher temperatures (over 15° C. or 59° F.) slight changes of atmospheric humidity very greatly alter the quantity of water that can be removed by respiration. Between the

skin and the kidneys a sort of reciprocal relation exists, the action of the kidneys increasing as the action of the skin diminishes, and conversely. Atmospheric humidity, in so far as it diminishes the loss of water by the skin, tends to increase the flow of urine.

These facts show that a dry climate has actually the "drying" character on the lungs commonly ascribed to it. The dryness of the nose and throat, usually complained of when a dry climate is first visited, is traceable to this cause.

### Influence of Humidity on the Digestive System

On the digestive system the amount of moisture in the air has a certain influence. The greater evaporation from the skin in a dry atmosphere tends to give rise to constipation, while the diminished secretion from the skin in moist air is apt to be compensated for by augmented secretion from the bowels. Thus it often happens that persons who have suffered from dysentery have a recurrence of their ailment in damp weather. The action, however, is indirect; and if a great amount of perspiration be carried off by wind, constipation may equally result in spite of the damp atmosphere, as is frequently the case on sea-voyages.

### Influence of Humidity on the Nervous System

On the nervous system also the action of humidity is indirect. A damp climate is said to be soothing, enervating, or depressing, according to circumstances, such as the individual reaction, the temperature of the air, and the amount of wind. The means by which humidity exerts its influence on the nervous system are threefold. (1) It increases the difficulty of getting rid of surplus heat, and thus tends to retard all vital actions which are accompanied by increased development of heat; (2) the stimulus due to alternations of heat and cold is very greatly diminished; (3) the electric conditions of the atmosphere are altered. To what extent this last-named agency is at work we cannot at present say.

## Influence of Humidity on Micro-Organisms

Apart from its indirect influence on the body, atmospheric moisture has another important function. It greatly influences the development of micro-organisms. A shower of rain washes the air, and carries down the solid particles floating about. But as moisture is indispensable for the growth of bacterial life generally, rain succeeding a period of dry weather is followed by the active development of the lower organisms; and as soon as the soil becomes dry again, the micro-organisms are carried with the dust into the air. With long continued dryness a diminution takes place in the vitality and number of these smallest of living things. Their time of greatest abundance in the air coincides with the period following a shower after a drought. Their time of least abundance is while rain is coming down. (Cf. p. 10.)

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# CHAPTER X

## INFLUENCE OF ATMOSPHERIC PRESSURE

### General Considerations

The physiological action of compressed and of rarefied air has in recent times attracted more attention than has the action of any other meteorological element. Before the end of the sixteenth century any effects produced in mountain climbing were either ascribed to cold and fatigue, or were disregarded. Acosta, a Spanish Jesuit father in Peru, was the first writer to give an account of "mountain sickness": faintness with shortness of breath and a thumping heart, often attended with vomiting, and occasionally with slight hæmorrhages from the upper air passages.

The growing popularity of mountain excursions, as well as the numerous expeditions in the highlands of South America, led to repeated descriptions by later explorers. The subject grew more and more interesting to the scientific mind, and innumerable theories were put forward to account for the phenomena.

The invention of the barometer in 1643, the fall in the barometric column on ascending a mountain, surmised by Pascal and found by Périer, acting under Pascal's direction, to be true, the invention of balloons in 1783, and of Triger's apparatus in 1839, enabling labourers to work deep under water by means of compressed air, are landmarks in the history of the subject. The occurrence of alarming symptoms in climbing mountains and in high balloon ascents; the

death in one balloon ascent of two out of three aeronauts, who a few hours before had left the surface of the earth full of life and vigour; the paralysis and death that so frequently happened to workers under water, not while they were in the compressed air, but after returning to the ordinary atmospheric pressure;—all these circumstances fixed the attention of scientific men and of the public alike on the phenomena, their causes, and possible remedies.

Moreover, from another source interest arose in regard to the effects of continuous residence in the mountains. Dr. Jourdanet, a French physician practising in Mexico, published in 1861 an account of the country and of the diseases to which its inhabitants were liable. The gist of his view was that the dweller in the mountains, being supplied with an insufficiency of oxygen, was for all practical purposes in the same condition as the dweller in the lowlands who suffered from insufficiency of red-blood corpuscles. In both cases there was an inadequate supply of oxygen to the system. The condition in the lowlands was dependent on anæmia; in the mountains on anoxhæmia. Jourdanet made several statements in contradiction with the prevailing views; and though his facts were shadowy, he supported them with much literary ability, and replied to his critics with great acumen. An observer was sent by the Académie des Sciences to examine the facts independently. Chief amongst the questions in dispute were the comparative activity of respiration and of the intra-organic oxidations, and the size of the chest-wall in mountain dwellers as compared with lowlanders.

Dr. Coindet, who was chosen for the purpose, traversed Jourdanet's statements almost along the whole line. Coindet himself was in turn severely criticised, and several weak points were exposed both in his observation of facts and in the inferences he drew.

Many of the points could be settled only by direct laboratory experiment; and Jourdanet generously provided the great French physiologist, Paul Bert, with the means of establishing the costly apparatus necessary for in-

vestigating the physiological action of compressed and of rarefied air.

Bert's work is a monument of experimental ingenuity, of literary industry, and of critical judgment. Besides his own researches he gives a full account of the records and views of previous labourers in the same field. Notwithstanding the great wealth of his material and the care and skill with which he worked, some of his conclusions have been overturned by later researches. The bulk of his work, however, still holds good.

A considerable body of facts has now been collected; though many gaps in our knowledge still remain.

The most fundamental point that has been made out is that the mechanical effects of pressure alone are almost nil, except during the change in pressure and shortly afterwards. Almost identical effects are produced by pure oxygen under a pressure of one atmosphere, and by ordinary air under a pressure of five atmospheres; or, again, by ordinary air at normal pressure, and by oxygen at a pressure of one-fifth of an atmosphere. This fact was established by Paul Bert, and, apart from slight modifications, has been confirmed by subsequent observers. L. Hill and J. J. R. Macleod[1] found in a recent investigation that ten atmospheres of air may be more damaging than two atmospheres of oxygen; but this result appears to be due to the greater loss of body heat owing to the higher conductivity of the moist compressed air.

It has further been shown that the physiological action of oxygen depends on the tension of the gas in the blood, which by no means keeps parallel with its tension in the air. The capacity of the blood to take up oxygen is peculiar. The red blood corpuscles have an affinity for oxygen, which upon contact with the hæmoglobin enters into a weak or loose chemical combination with it. This combination within certain limits is independent of pressure, except as concerns the rapidity of union. In the plasma, on the contrary, the absorption of oxygen is in accordance with Dalton's law, that the volume of a gas that can be

absorbed in a given liquid at a given temperature, though different for different gases, is always the same for the same gas. As the volume of a gas varies inversely as the pressure, it follows that the volume of gas absorbed remaining unaffected, the weight absorbed varies according to the pressure.

Now, though the hæmoglobin of the red corpuscles holds the oxygen chemically combined, the bond is very feeble; and the force exerted by the gas to free itself from the combination varies according to the external pressure of the gas; but the extent of the variations for pressures ranging from half an atmosphere upwards is still unsettled. According to Hüfner,[2] hæmoglobin when exposed to air under a pressure of one atmosphere—or what is the same, oxygen under a tension of one-fifth of an atmosphere, or six inches of mercury—takes up oxygen to within 1·5 per cent of saturation. Any increase in the tension of the oxygen causes increased absorption by the blood only in accordance with Dalton's law. When the tension of oxygen falls to three inches (its tension under half an atmosphere) the oxygen combined with hæmoglobin diminishes only 2 per cent; and when the tension of oxygen falls to two inches (one-third of an atmosphere), the oxygen combined with hæmoglobin in the blood at the body temperature is only 4·6 per cent less than under a pressure of one atmosphere. These figures represent, in Hüfner's view, the behaviour of hæmoglobin as it occurs in ordinary healthy blood; but the capacity of hæmoglobin for oxygen is in proportion to the amount of iron it contains and to the concentration of the solution; the stronger the solution of hæmoglobin, and the more iron the hæmoglobin contains, the more oxygen it can absorb. Hence one source of the different reactions of different individuals to the same degree of rarefied air.

A. Loewy[2] obtained considerably lower figures than Hüfner; and more recently Regnard,[3] on taking specimens of blood from a dog at atmospheric pressures ranging from 750 to 170 mm. Hg, found that the oxygen present

did not differ greatly in amount from what would be the case if it were simply dissolved according to Dalton's law. A. Mosso[4] also found 20 per cent less oxygen in arterial blood on Monte Rosa than at Turin.

Recent experiments by Bohr and by Krogh,[53] working with improved methods, gave results not unlike those of Hüfner, and seem to show that the red blood corpuscles seize oxygen more readily and hold it more firmly than would appear to be the case from the researches of Loewy, of Regnard, and of Mosso. Krogh found that the capacity of the blood to absorb oxygen is appreciably diminished in proportion to the amount of $CO_2$ present.

The oxidations in the body are due to the demand of the tissues, not to the amount of oxygen supplied, at least within certain limits. That increased oxidation of the tissues would result from an increased supply of oxygen was formerly supposed by many persons to be so natural as hardly to require verification. P. Bert, who invariably sought the guidance of facts, thought that he had obtained experimental proof that the intra-organic oxidations were at their highest degree of energy under a tension of oxygen corresponding to three atmospheres, or to air containing 60 per cent of oxygen. Later researches, however, by other observers have shown that the changes in the activity of intra-organic oxidation under pressures varying from half an atmosphere to three atmospheres are only such as might occur independently of altered pressure.

Oxygen under high tension, that is to say, pure oxygen under a pressure of from one to three atmospheres, corresponding to its tension in the air at a pressure of from five to fifteen atmospheres, proves fatal not merely to all animal but to vegetable life including microscopic organisms. Seeds that have been exposed to oxygen under high tension no longer germinate. The fatal point is reached when the quantity of oxygen in the blood amounts to 35 per cent by volume.[5] Even when the proportion of oxygen in the air is only slightly increased, plants and animals do not thrive so well as in ordinary air. The general conclusion seems

to be established that the tension of oxygen as it exists in the air is the most suitable for the healthy life of plants and animals.

The inferior limit compatible with life varies according to the species.

Sparrows begin to be restless at a pressure of about half an atmosphere; at about 25 cm. (one-third atmosphere) the animal begins to vomit, to stagger, and soon falls. It dies usually at a pressure of 17 or 18 cm.; though with great care a pressure of only 10 cm. may be reached.[6]

Cats are almost equally susceptible with sparrows to diminished pressure. At a high altitude cats are difficult to rear, and die rapidly. At Cerro de Paseo (4350 metres) cats are uncommon, and the young ones are hard to bring up.[7] "Cats," according to Tschudi, "cannot live above an altitude of 13,000 feet. Attempts have often been made to introduce them into the high-lying valleys, but always in vain; for after some days they were seized with horrible epileptiform convulsions, to which they succumbed. Dogs are likewise affected, but not so severely."[8]

Hens lay and hatch but little at high altitudes.

Guinea-pigs and rabbits stand low pressure well.[9]

Germination of seeds no longer takes place when the barometric pressure is reduced to about 7 cm., which corresponds to 2·5 cm. tension of oxygen—a level at which warm-blooded animals succumb rapidly, whatever precautions may be taken, and at which even cold-blooded vertebrates cannot long continue to live.

The mechanical effects of increased and of diminished pressure arise during the change of pressure or shortly afterwards. When the atmospheric pressure is quickly increased, the surface blood-vessels become anæmic and the conjunctiva pale. The gases in the intestines being under lower pressure, the abdominal walls are compressed and the diaphragm driven down. By the descent of the diaphragm the thoracic cavity is enlarged, and the respiratory capacity becomes greater.

## Influence of Atmospheric Pressure on Circulation and Respiration

The ways in which changes in atmospheric pressure modify the circulation and the respiration are to a certain extent no longer in dispute; but many points still remain unsettled, in spite of much experimental laboratory work and the accumulated records of mountain and balloon excursions, as well as observations on divers and other workers in compressed air.

The pulse rate and the rate of breathing are affected by the density of the air. This is now admitted by all physiologists; though enormous differences in susceptibility are noticeable in different individuals.

The modifications in pulse rate and in the rate of breathing, as well as the discrepancy of result in different persons, will be seen on examining the records of various observers.

The observations of Von Vivenot and his fellow-workers I have thrown as far as possible into tabular form on the following page.

The influence of compressed air on the respiratory capacity is, according to Von Vivenot, not transient, but in part permanent; so that by the employment of compressed air for two hours daily the respiratory capacity is, up to a certain point, every day 20 ccm. to 30 ccm. greater than it was the day before. Von Vivenot took 122 compressed air baths from April 30 to September 19, that is, 143 days; and during this time his respiratory capacity went up from 3051 ccm. to 3794 ccm. (and in compressed air even to 3981 ccm.). This increased capacity was reached in three and a half months on August 12 after ninety-one baths, and was afterwards maintained at practically the same level.[11]

[Table

TABLE SHOWING INFLUENCE OF NORMAL AND OF INCREASED PRESSURE ON VON VIVENOT AND FELLOW-WORKERS.[10]

| Name of Observer. | Vital Capacity. | | Respirations per Minute. | | Pulse. | |
|---|---|---|---|---|---|---|
| | In Normal Air. | In Air under $1\frac{3}{7}$ Atm. Pressure. | In Normal Air. | In Air under $1\frac{3}{7}$ Atm. Pressure. | In Normal Air. | In Air under $1\frac{3}{7}$ Atm. Pressure. |
| G. Lange . . | cc. 3950 | cc. 4083 (+133) | 19<br>16 (after 4 seances in 11 days) | 14<br>6 (after 4 seances in 11 days) | | |
| Mittermaier . | 4159 | 4280 (+121) (after a single experiment) | | | | |
| M. H. . . | 2910<br>2900 | 3009 (+99)<br>3085 (+185) (after 11 days) | 21<br>16 (after 12 days) | <br>13 (after 12 days) | | |
| Von Vivenot . | 3425 | 3533 (+108) | 20–16<br>4·5 (after 3 months) | ...<br>3·4 (after 3 months) | 79·03 | 72·41 And on leaving the compressed air did not, during the day, remount to its previous level. |
| | | | | | This change occurred 375 times out of 423 observations; 18 times there was no change, and 30 times there was an acceleration of the pulse. | |
| M de K. . . | 3252 | 3664 (+412) (in 4 days) | | | | |
| M. G. . . (emphysematous) | 2202 | 2550 (+348) (in 17 days) | 20·5 | 15·5 | | |
| D. D. . . | ... | ... | 33 | 18 (2nd day)<br>10·4 (in 5 days) | | |

INFLUENCE OF NORMAL AND OF DIMINISHED ATMOSPHERIC PRESSURE ON VON VIVENOT AND FELLOW-WORKERS.

| Name of Subject. | Vital Capacity. | | Respiration. | | Pulse. | |
|---|---|---|---|---|---|---|
| | In Normal Air. | In Air at 434 mm. pressure (=4470 metres above sea-level). | In Normal Air. | In Air at 434 mm. pressure. | In Normal Air. | In Air at 434 mm. pressure. |
| | ccm. | ccm. | | | | |
| Lange | 3942 | 3448 (494) | 15 | 21 | 73 | 82 |
| Mittermaier | 4237 | 3843 (394) | 7·5 | 9·5 | 78 | 80 |
| M. de G. | ... | ... | 17 | 21 | 61 | 75 |
| Von Vivenot | ... | ... | 14 or 15 | 18 | 80 | 105 |

An increase in the depth of the inspirations was noticed by Von Vivenot in rarefied air; the effect in this respect being the same as in compressed air, though the cause was different. In compressed air the deeper inspiration seemed to be the spontaneous mechanical effect of the greater pressure. In rarefied air, on the contrary, deep and forced inspirations were due to the need for air which could not be satisfied with the normal inspirations.

Inspiration, which even under ordinary pressure requires the expenditure of more muscular force than does expiration, was rendered difficult in rarefied air; expiration, on the contrary, becoming easier and quicker.

The greater capacity of the lungs under high atmospheric pressure may be assigned to the depression of the diaphragm owing to comparatively low tension of the intestinal gases.

Panum also investigated the physiological action of compressed air; and arrived at substantially the same conclusions as Vivenot, whose methods, however, he pointed out were very defective. His own methods have been dealt with in like manner by later critics.

From the time of De Saussure many observations on the circulation and respiration have been made in balloons and in the mountains. A few of these will be selected for

illustration. De Saussure's own researches are amongst the most interesting of their kind. His repeated ascents, the long time he spent at great elevations, and the care with which he noted the facts, stamp his observations with special value even to the present day.

On one occasion he remained with his son on the Col du Geant at an elevation of 3360 metres for sixteen days —from July 3 till July 19, 1788.

He remarks: "On reaching the top we were much more out of breath than after an equal ascent in a lower mountain. The following days this inconvenience seemed to get less, and my companions as well as my son and myself thought we had got accustomed to the air. But when we paid attention to the matter, we found that on running or assuming an uncomfortable position, especially if the chest-wall was compressed, one got much more breathless than in the plains, and that in an increasing degree, so that from moment to moment it became more difficult and even impossible to keep up these efforts."[12]

M. Lortet of Lyons made careful tracings of the movements of the chest-wall and of the radial pulse on the top of Mont Blanc. The pulse and respiration rates at different heights are summed up in the following table[13]:—

| | Pulse. | | Respiration. | |
|---|---|---|---|---|
| | At Rest and Fasting. | Moving. | At Rest. | Moving. |
| Lyons, 200 metres above sea | 64 | ... | 24 | ... |
| Chamounix, 1050 m. . | ... | 80 | 24 | ... |
| Grands-Mulets, 3050 m. | ... | 108 | ... | ... |
| Grand-Plateau, 3952 . | ... | 116 | 24 | 36 |
| Bosses-du-Dromedaire, 4556 m. | ... | 128 | ... | 36 |
| Sommet de la Calotte . | ... | 136 | ... | 36 |
| ,, du Mont Blanc, 4810 m. | 90 to 108 | 160 | 25 (after 2 hours' rest) | 36 |

Mermod's [14] researches are also highly instructive. During some months he counted his pulse and respiration at four places of different altitude :—

MERMOD'S OBSERVATIONS ON PULSE RATE.

| Strasburg, 142 m.above Sea. | Erlangen, 323 m. | Lausanne, 614 m. | Sainte Croix, 1090 m. |
|---|---|---|---|
| 64·90 (287 observ.) | 65·26 (840 observ.) | 68·09 (473 observ.) | 68·71 (896 observ.) |

MERMOD'S OBSERVATIONS ON RESPIRATION

| | Strasburg, 142 m. above Sea. Temp. 12° 65 C. Bar. 745 mm. | Sainte Croix, 1100 m. Temp. 12° 68 C. Barom. 669 mm. |
|---|---|---|
| Number of respirations per minute | 11·15 | 11·24 |
| Volume of gas expired per minute | 5 litres 85 ccm. | 6·27 |
| This volume reduced to 0° C. and 760 mm. | 5 litres 48 ccm. | 5·27 |
| Volume of each expiration . | 524 ccm. | 557 ccm. |
| This volume reduced to 0° C. and 760 mm. | 491 ccm. | 469 ccm. |
| Weight of $CO_2$ expired per minute | 0 gr. 375 | 0 gr. 402 |
| Percentage of $CO_2$ in expired air | 5·507 | 6·098 |

Thus in Mermod's case the air inspired in a given time as well as in each inspiration was greater in volume but less in weight at St. Croix than at Strasburg.

An account given by Wood [15] of observations made on the Plateau of Pamir, 15,600 feet above sea-level, is worthy of mention.

One evening sitting quietly in his tent he chanced to feel his pulse. Its rapid and tumultuous action attracted his attention, and he thought he was in a violent fever. Next morning he found the pulse as quick as the evening before; nevertheless he felt perfectly well. He then examined the pulse of his companions; and to his surprise found it in each case more rapid than his own. Afterwards he counted his pulse whenever he registered the boiling-point of water; and found that the pulse rate was a kind of living barometer, by which a man accustomed to observe himself might at great altitudes roughly calculate the height:—

Pulse Rate on the Pamir, 15,600 Feet

| | |
|---|---|
| Self (Wood) . . . . | 110, Scotchman, stout |
| Gholam Hussein, munshi . | 124, Jasulmeere, ,, |
| Omer-Allah, muleteer . . | 112, Afghanistan, thin |
| Gaffer, servant . . . | 114, Peshawuree, ,, |
| Dowd . . . . . | 124, Kabul, robust. |

The snow limit in this region is above 17,000 feet.

Henderson[16] gives an interesting account of observations made during Forsyth's expedition from Lahore to Yarkand in 1870. On July 10 in the Pass of Chang-La, leading from the basin of the Indus to that of Shyok at an elevation of 18,000 feet, the following points are noted:—

| At 15·73 inches merc. barom.; 61° F.; 187° F. boiling-point of water. | | |
|---|---|---|
| | Pulse. | Respiration. |
| Henderson (walked to summit) . . | 80 | 26 |
| M. Forsyth (on horseback) . . . | 100 | 22 |
| Shaw . . . . . . . . | 94 | ... |
| M. Kutub Deen (from the Punjab) on horseback | 92 | ... |
| A Hindoo (on foot) . . . . . | 93 | ... |
| A Thibetan . . . . . . | 78 | ... |

Henderson himself, even at 19,600 feet, never felt much discomfort. It never amounted to more than a certain shortness of breath after exercise, and waking up in the night with a feeling of suffocation which generally passed off after a few deep inspirations. But the symptoms with several members of the party were more serious and sometimes alarming. A great excitability of character was also another peculiarity.

Henderson says that the few isolated observations he has been able to make show that on him, at any rate, altitude has but little effect. Numerous observations yielded similar results :—

| | Pulse. | Respiration. | Temperature under Tongue. |
|---|---|---|---|
| Ordinarily . . . . | 80 | 24 | 98·2 |
| At Sakte (seated several hours) 12,900 feet, July 9 | 90 | 25 | 98·3 |
| Summit of Chang-La 18,000 feet (5485 m.) walked to the top | 80 | 26 | ... |
| Lak Zung, more than 17,500 feet, July 24 | 75 | 24 | 97·8 |

In September 1894 Professor Kronecker of Berne organised and carried out a scientific expedition from Zermatt to the plateau of the Breithorn. Several members of the party were carried up in order to avoid the effects of fatigue or exertion. The altitude of the lower station was 1600 metres; of the higher station 3750 metres. The following table, taken with slight modifications from Kronecker,[17] shows the chief results :—

[TABLE

| Name. | Pulse. Zermatt Breithorn. | | | Vital Capacity. Zermatt Breithorn. | | Hæmoglobin Percentage. | Observations. |
|---|---|---|---|---|---|---|---|
| | Rest. | Rest. | Motion. | | | | |
| Interbinnen, 10 years old | 84 | 120 | 132 | 1200 | 1250 | 90 | Neither dyspnœa nor palpitation, 4.30 P.M. |
| Frau Sahli, 20+ years old | 96 | 106 | 140 | 2650 | 2510 | 95 | Slight dyspnœa, palpitation, slight cyanosis |
| Frau Kronecker, 30+years old | 85 | 100 | 136 | 2500 | 2550 | 85 | Standing on plateau, pulse 112, after 20 steps, p. 136 |
| Professor Sahli, 40+years old | 94 | 106 | 144 | 3500 | 2750 | 100 | Palpitation, dyspnœa, slight cardiac murmur, lying on Breithorn, p. 100 |
| Professor Kronecker, 50+ years old | 64 | 80 | 120 | 2625 | 2200 | 100 | When walking, palpitation and dyspnœa, slight palpitation after 35 strokes of axe at intervals of one second, p. 108 |
| Pern (peasant in Zermatt), 73 years old, not a climber | 70 | 80 | 120 | 1900 | 1500 | ... | Standing, p. 100, after 70 strokes with pick, p. 120, some dypsnœa, palpitation after 20 steps upwards |
| Herr Asher, 30+ years old | 74 | 112 | 120 | 2340 | 1960 | 110 | In Zermatt after 2 decilitres of Dôle, p. 84 |
| Herr Bartel (attendant in Physiological Institute, Berne) | 94 | 120 | 160 | 3800 | 3250 | 110 | Mountain sickness, dizziness, no palpitation, can photograph with difficulty |
| Guide Pern, 30 years old | | 100 | 140 | ... | | ... | Slight palpitation and dyspnœa after 20 steps |
| Guide Kronick, 37 years old | | 108 | 120 | ... | | ... | After 20 steps transient dyspnœa |
| Carrier Pinder, 24 years old | | 108 | 140 | ... | | ... | After 20 steps palpitation, but no dyspnœa |

Mosso [18] gives an instructive table of observations made by Dr. Gurgo on the rate of the pulse and of the breathing during a sojourn of three days at the Regina Margherita Hut (altitude 4560 metres). In all the members of the party, fifteen in number, the pulse rate quickened during the first day, the increase ranging from 18 to 49 beats over the normal rate of the various subjects. On the second day in some of the subjects the pulse was even more rapid than on the first day; in other subjects there was a slight decline in the frequency of the pulse. On the third day the pulse rate had in nearly every case fallen

considerably, in some instances almost reaching the normal rate in the lowlands.

In regard to respiration the results were by no means so uniform. In most instances the breathing was accelerated during the first two days, sometimes more on the second day than on the first. In a couple of instances the breathing was actually slower, either the first day or the whole time, than in the lowlands. On the third day the respiration in every instance had fallen, mostly either to or about the normal rate or lower.

In the case of several of the subjects a kind of periodic respiration either during sleep or in the waking state was noted. This periodicity took the form of a pause after 5-8 respirations, or of periods of greater or less amplitude, or of typical Cheyne-Stokes breathing.

In this connection I may mention that I have often observed Cheyne-Stokes respiration in trivial ailments at Davos (1560 metres).

The foregoing records show how differently different people are affected by altered atmospheric pressure. The explanation lies no doubt in the varying individual capacity of the lungs and blood to supply the required amount of oxygen to the tissues. The amount of oxygen required, depending upon the loss of heat and other causes, varies also from person to person.

Whether arterial tension is affected by altered atmospheric pressure has been a subject of much discussion. The experimental evidence has been contradictory. Bert thought the conclusion warranted that arterial tension is raised by increased atmospheric pressure. Friedländer and Herter found the tension raised by diminished atmospheric pressure.

Fraenkel and Geppert found the arterial tension quite unaffected by changes in the pressure of the air. In any case the results are not likely to be always the same in different people, arterial tension being itself the result of many forces.

The sphygmographic tracings taken by Lortet on a strong young man on the Grands Mulets (3000 m.) indicate lower arterial tension than at Chamounix (1000 m.). Conway's

tracings[19] in the Himalayas can hardly be said to point very distinctly to altered blood-pressure. But if there is a change, it is, except in the case of one observation, rather in the direction of lowered tension.

Professor Angelo Mosso[20] found that in drugged animals the blood-pressure was not altered by rarefaction of the air corresponding to an altitude of 6500 to 7000 metres. From numerous observations made on Monte Rosa he concluded that diminished barometric pressure at a height of 4560 metres did not modify the physiological conditions of the blood-vessels either in his companions or in himself.

Some of the sphygmographic tracings taken by Professor Kronecker showed signs of low tension. Kronecker[21] sums up the facts concerning the form and rate of the pulse as follows:—

1. At considerable heights (3000 metres and more), during the first days of the stay, the pulse rate is greater in most people, even during rest, than in the lowlands.

2. After comparatively slight and temporary (one to two minutes) exertion on high mountains, the pulse increases more in frequency than in similar conditions in the lowlands. At the same time the pulse changes in form, becoming like the pulse of fatigue. This change subsides again after a few minutes.

3. After exertion for an hour or more at low or moderate elevations the characters of cardiac excitement and vascular fatigue last for perhaps eight hours, and upon the highest mountains even a whole day.

4. Men in training exhibit, even after walking an hour or more, only transient quickening of the pulse.

Much work has been done to show the influence of altered atmospheric pressure on the amount of oxygen absorbed by the lungs, and the amount of carbonic acid excreted. The results obtained by different observers are somewhat discordant, and present considerable individual differences. Mermod's observations have been already quoted (p. 113). Amongst the most recent investigations are the very careful and exact observations of Dr. E. Burgi,[22]

a pupil of Professor Kronecker's. Burgi's researches were made in 1898 and 1899 at Berne (460 metres above sea-level), at Brienz (570 metres), on the Rothorn (2252 metres), and on the Gornergrat (3038 metres). At the higher stations the excretion of carbonic dioxide during rest was not materially greater than at the lower levels. He found, further, that the same work at a high elevation raises the respiratory exchange more than at the foot of the mountain; but as a result of training at a high altitude the respiratory exchange of the mountaineer is diminished, so that an equal ascent at the summit and at the foot of the mountain causes an equal excretion of carbonic acid.

## Influence of Atmospheric Pressure on the Prevalence of Heart Diseases

Organic diseases of the heart are sometimes said to be more frequent in mountainous regions; the strain on the respiratory and circulatory systems in climbing hills in the rarefied air being ascribed as a cause. The evidence on the subject is not conclusive, contradictory accounts being given from different countries as to the prevalence of cardiac affections.

A careful examination of the causes of death in Switzerland was made by Dr. Neonilla Iwanoff[32] with special reference to this point. Her results may be tabulated as follows:—

Annual Death-rate in Switzerland from Organic Heart Disease per 100,000 living Persons

| | |
|---|---|
| 1. Lowlands (20 to 400 metres above sea-level) | 102 |
| 2. Hill country (400 to 700 metres) | 92 |
| 3. Mountainous districts (700 to 1200 metres) | 82 |
| 4. High alpine regions (1200 metres and more) | 47 |

In these statistics, however, no account is taken of the prevalence of heart disease according to occupation. A table given by Professor A. Vogt in a supplement to Miss Iwanoff's essay shows that those callings in which heart disease is most frequent are those which occur most frequently in the more thickly populated districts of the lowlands. This table is of so much interest that I reproduce it.

| Vocations. | Number of Recruits. | | Amongst 1000 Recruits Examined, number of cases of Heart Disease. |
|---|---|---|---|
| | Medically Examined. | Unfit for Service on Account of Organic Disease of the Heart. | |
| 1. Locksmiths . . . . | 1,670 | 4 | 2 |
| 2. Cartwrights. . . . | 908 | 2 | 2 |
| 3. Joiners . . . . | 1,189 | 3 | 3 |
| 4. Masons . . . . | 2,074 | 9 | 4 |
| 5. Butchers . . . . | 1,780 | 6 | 4 |
| 6. Carriers and drivers . . | 912 | 4 | 4 |
| 7. Smiths . . . . | 1,432 | 7 | 5 |
| 8. Coopers . . . . | 602 | 3 | 5 |
| 9. Bakers . . . . | 2,230 | 13 | 6 |
| 10. Railway men . . . | 817 | 5 | 6 |
| 11. Factory workers . . . | 2,406 | 18 | 7 |
| 12. Tailors . . . . | 1,211 | 9 | 7 |
| 13. Gardeners . . . . | 917 | 6 | 7 |
| 14. Farming and dairy workers . | 55,426 | 431 | 8 |
| 15. Mechanics . . . . | 1,735 | 15 | 9 |
| 16. Tinkers . . . . | 584 | 5 | 9 |
| 17. Printers . . . . | 667 | 7 | 10 |
| 18. Millers . . . . | 594 | 6 | 10 |
| 19. Post and telegraph clerks . | 506 | 5 | 10 |
| 20. Watchmakers . . . | 5,412 | 60 | 11 |
| 21. Cabinet-makers and glaziers . | 1,992 | 21 | 11 |
| 22. Shoemakers . . . | 2,640 | 31 | 12 |
| 23. Embroiderers . . . | 2,948 | 39 | 13 |
| 24. Spinners, weavers, etc. . . | 2,770 | 35 | 13 |
| 25. Waiters, etc. (hotel servants) . | 1,275 | 16 | 13 |
| 26. Students . . . . | 1,443 | 60 | 17 |
| 27. Painters . . . . | 787 | 13 | 17 |
| 28. Confectioners . . . | 523 | 9 | 17 |
| 29. Teachers . . . . | 887 | 17 | 19 |
| 30. Saddlers . . . . | 635 | 12 | 19 |
| 31. Tradesmen, clerks, etc. . . | 8,507 | 173 | 20 |
| All other vocations . . | 12,759 | 96 | 8 |
| Totals and Averages . . | 120,238 | 1140 | 9 |

Hirsch,[33] on the contrary, speaks of dilatation and hypertrophy of the heart as being specially frequent in mountainous regions. "We have," he says, "detailed information on this head from the tablelands of Persia and Mexico, and from the Italian Alps and some mountainous parts of Germany. Thus the Wurtemberg recruiting lists show that heart disease is relatively commonest in the circles of the Jaxt and Black Forest, and specially in the more elevated districts; and Ozlberger calls attention to the strikingly frequent occurrence of cardiac hypertrophy among the mountaineers of Upper Austria."

The truth probably is that rarefied air, in so far as it augments the strain thrown on the heart by exercise, does actually tend to develop cardiac disease.

In my own observation it has appeared that persons who have come up to the mountains with mitral incompetence have generally complained of discomfort from the rarefied air. Persons affected with aortic disease, on the contrary, have but rarely suffered inconvenience. A special strain falls on the right ventricle when the blood is insufficiently aerated; and this, as we have seen, occurs in extremely rarefied air, also when active exercise is taken in air not so highly rarefied.

Cardiac discomfort is felt by some persons on arriving in Davos and for a few days afterwards. Ordinarily the sensation amounts only to a vague feeling of uneasiness in the cardiac region. Palpitation, with breathlessness, is a comparatively rare symptom; though waking up at night with a sense of suffocation is not very unusual, especially in fat and flatulent women, for some nights after arrival. Such discomfort commonly passes off, and the heart adjusts itself to the work it has to do. This at any rate is the case in persons endowed with a fair amount of vigour. Mountain air acts as a tonic for the weak heart of persons flabby from illness or lack of exercise who have a good reserve of vitality. The important point in such cases is to be very chary of exercise till the heart has to some extent adapted itself to its surroundings, otherwise cardiac overstrain is inevitable.

## Influence of Atmospheric Pressure on the Prevalence of Phthisis

The infrequency of phthisis at great elevations having struck some observers, the doctrine of immunity or relative immunity from the disease at high altitudes sprang up. The limit supposed to confer immunity varied according to latitude. Jourdanet fixed it about midway between the line of perpetual snow and the sea-level. At the Equator it would be at about 2400 metres (7872 feet); in Mexico, at 2250 metres (7380 feet); in Switzerland, at 1350 metres (4426 feet); in the Polar regions, almost at sea-level.

In densely populated towns, however, at a great altitude, such as Mexico, Bogota, and Quito, often cited as examples of comparative immunity, the disease is common. In Mexico, 2300 metres (7544 feet) above sea-level, Jourdanet,[34] a zealous upholder of the immunity doctrine, represents the death-rate from phthisis as 2·1 per 1000 living, and as forming 5·7 of the entire mortality. Other statistics give a much higher figure. According to Le Roy de Méricourt,[35] the general death-rate amounts to 42 per 1000 living, and of this high mortality phthisis forms the ninth part or 11·2 per cent—that is, 4·7 per 1000 living. In Bogota, according to Restrepo,[36] at an elevation of 2600 metres (8528 feet), with a population of 40,000, and in Quito, according to Jacoby,[37] 2850 metres (9348 feet) above sea-level, phthisis enters largely into the mortality lists. Jacoby tells us that he saw at La Plaz in Mexico, 11,000 feet high, cases amongst persons who had never left the district.

Restrepo, in his interesting and careful essay, gives many useful details concerning the disease at Bogota. The persons affected by it appear to belong to the lowest and poorest class of the population, who live in the most deplorable hygienic conditions. The food of these poor people is remarkable. In the form of animal food they have, not the muscular part or meat, but the viscera—lungs, liver, kidneys, and intestines. These portions are eaten almost raw or very slightly cooked. Now Restrepo tells us also

that about 50 per cent of the cattle that reach Bogota from the lower country and 10 per cent of the cattle of the Plateau of Bogota are affected with tuberculosis. The parts of the animal chiefly affected by the disease are the very parts eaten by the poor people.

The form of the disease is peculiar, and appears to stand in relation with the diseased food. The intestines are always affected. The disease as it affects the lungs does not attack the apex more frequently than other portions, masses of tubercle being distributed throughout. There appears to be remarkably little tendency to the formation either of cavities or of fibroid tissue. The tubercular masses undergo, not calcareous, but fatty degeneration; and they rarely cause any local reaction either in the lung tissue or in the bronchial tubes. The symptoms, too, of the disease as it affects the lungs, differ remarkably from the symptoms of pulmonary tuberculosis as we know it. The disease runs a very chronic course; the temperature is usually subnormal; there are no night sweats; hæmoptysis is very rare; and very seldom is there either cough or expectoration. Dr. Restrepo says: "Cough is a rare phenomenon in the course of our phthisis; the majority of our patients have never coughed, or have had only some coughing fits at the beginning of the disease when that has closely followed an affection of the respiratory passages, such, for example, as measles. This cough disappears quickly, to reappear only when there is some acute inflammatory trouble in the pleura. Then the cough is dry and tearing, not at all resembling the ordinary cough of consumptives." Laryngitis, too, is a rare occurrence. The symptoms of the disease resolve themselves into intractable diarrhœa, digestive troubles, and emaciation.

The peculiar manifestations of the disease and the absence of pulmonary symptoms explain to a great extent the divergence of opinion as to the prevalence of tuberculosis.

South American statistics are not very trustworthy; and we shall probably have to wait a good while still before we have any very exact knowledge of the comparative frequency of

tuberculosis at different elevations in South America. There can, however, be little question that the disease is much more prevalent in the less elevated regions, even when these lower regions are much less thickly populated.

Hirsch gives statistics from a great many different places, all pointing to diminished frequency of the disease with increasing elevation.

The Sanitary Department of the Grisons in Switzerland made an inquiry as to the prevalence of tubercular diseases amongst the native population at various elevations throughout the Canton in 1895. Of 690 cases of tubercular disease 480 were of the lungs. The following table shows the distribution :—

| Number of Communes. | Metres above Sea. | Population. | Tubercular. | Per mille. |
|---|---|---|---|---|
| A . . 15 | 285-599 | 20,369 | 246 | 12·48 |
| B . . 40 | 600-999 | 20,935 | 204 | 9·74 |
| C . . 64 | 1000-1499 | 25,346 | 182 | 7·18 |
| D . . 19 | 1500-1880 | 10,291 | 58 | 5·64 |
| Total . 138 | 285-1880 | 76,941 | 690 | 8·97 |

The average population of a commune in each of the foregoing groups is as follows :—

| | |
|---|---|
| A . . . | 1358·0 |
| B . . . | 523·4 |
| C . . . | 396·0 |
| D . . . | 541·6 |

Thus the prevalence of tubercular disease diminishes steadily with altitude, although the communes of greatest altitude are more populous than the two groups of communes next below them.

The figures just given refer to the morbidity or prevalence of the disease, not to the mortality. If the average duration of the disease be taken as three years, then the morbidity divided by 3 would give the mortality or proportion that die of the disease yearly.

The diminished frequency of tuberculosis with altitude

may, I think, be taken as established. As to the explanation of the fact various views are held. According to some, the diminished frequency of the disease is due simply to the greater sparseness of the population. This view, as we have seen, is untenable; in cases where the population is greater at the higher altitude the disease is less frequent than in the more sparsely occupied regions lower down in the same country.

Hirsch ascribes the diminished frequency of phthisis at high altitudes to the greater functional activity of the lungs called for by the rarefied air. The deeper breathing often required in the mountains causes a more thorough ventilation of the lungs, which helps to keep them healthy and more resistent to disease.

Hirsch's explanation is no doubt correct as far as it goes, but other factors deserve consideration. The greater diathermancy of the air permits more vigorous action of the sun's rays on the disease germs. The greater cold and, as a rule, also the greater dryness of the air at high altitudes are unfavourable to the life of the bacillus.

### Influence of Atmospheric Pressure on other Diseases of the Respiratory System

The prevalence of other diseases of the respiratory system does not appear to stand in any direct relation with altitude. Pneumonia and bronchitis are frequent in some elevated regions, and comparatively rare in others. In Mexico and other high-lying districts of the Andes, the mortality from these diseases is great. In the Cordilleran region of the United States, having an elevation from 4000 to 10,000 feet, pneumonia is frequent in Nevada and Colorado, giving a death-rate in each of these states of 2·3; while in Arizona the death-rate from the same cause is only 0·74, and in Wyoming and Montana, 0·81 and 0·82 respectively.

The following table, compiled from statistics given by Hirsch, Davidson, and Toner, shows the death-rate from pneumonia in different places according to altitude:—

| | Altitude. | Period. | Death-rate from Pneumonia. |
|---|---|---|---|
| | Feet. | | |
| 1. London . . | 50 | 1848-55 | 1·7 |
| " . . | " | 1903 | 1·3 |
| 2. Paris . . | 210 | 1839-50 | 2·5 |
| 3. Connecticut . | 300 | ... | 1·25 |
| 4. West Virginia . | 1050 | ... | 0·7 |
| 5. Geneva . . | 1338 | 1843-45 | 1·3 |
| 6. Montana . . | 4500 | ... | 0·82 |
| 7. Nevada . . | 5400 | ... | 2·36 |
| 8. Upper Engadine | 5750 | 1861-70 | 1·8 |
| 9. Colorado . . | 6500 | ... | 2·35 |
| 10. Wyoming . . | 7200 | 1880 | 0·81 |

As with pneumonia, so with other ailments of the respiratory system. Altitude alone counts for little; variations in atmospheric humidity count for a great deal, especially when acting in combination with irregular variations in wind.

The low absolute humidity at high altitudes causes the air, as it is heated during inspiration, to absorb much moisture from the air passages and lungs. The nose and throat are most exposed to this desiccation. M. Gay-Lussac, in a balloon ascent, at 7016 metres (23,012 feet), found his throat so dry that swallowing became painful. Similar facts are recorded by other observers. This dryness of the throat increases its sensitiveness to dust and other sources of irritation. Under the same influence excessive nasal secretion diminishes. This action is, of course, not peculiar to high altitudes, being common to all climates where the humidity, relative or absolute, is low.

### Influence of Atmospheric Pressure on the Blood

Specimens of the blood of animals that had lived at great elevations in the Andes were sent to P. Bert, and he found that such blood absorbed a much larger quantity of oxygen than is the case with lowland animals of the same kind. A very remarkable change in the corpuscular rich-

ness of the blood has within recent years been noted by many observers to correspond with diminished atmospheric pressure. The results are set out in the following table :—

| Place. | Altitude in metres. | Red Blood Corpuscles per cubic millimetre. | Observer. |
|---|---|---|---|
| Christiania . | Sea-level | 4,974,000 | Laache. |
| Göttingen . | 148 | 5,225,000 | Schaper. |
| Basle . . | 266 | 5,169,000 | Karcher. |
| Tübingen . | 314 | 5,322,000 | Reinert. |
| Zürich . | 411 | 5,752,000 | Stierlin. |
| Goerbersdorf | 561 | 5,800,000 in healthy men | Jaruntowski and Schroeder. |
| ,, | ,, | 5,244,000 ,, women | ,, |
| Serneus . | 985 | 6,084,000 | Suter. |
| Champéry . | 1052 | 5,712,000 | Karcher. |
| Leysin . | 1450 | 6,048,000 in healthy men | Radovici. |
| ,, | ,, | 5,760,000 ,, women | ,, |
| Davos * . | 1560 | 6,551,000 ,, men | Kündig. |
| ,, | ,, | 5,804,000 ,, women | ,, |
| ,, | ,, | 6,290,000 ,, men | Van Voornveld (used Meissen's chamber). |
| ,, | ,, | 5,595,000 ,, women | ,, |
| Arosa . . | 1800 | 7,000,000 (min. 6,350,000 to max. 7,320,000) in ten healthy men | Egger. |
| ,, | ,, | 6,500,000 in one healthy woman | ,, |
| ,, | ,, | 6,529,000 in five healthy men | Roemisch (Thoma's chamber). |
| ,, | ,, | 6,315,000 in two ,, | Roemisch (Meissen's chamber). |
| Cordilleras . | 4392 | 8,000,000 | Viault. |

Discrepant reports have been astonishingly few. Kohlbrugge,[23] at the Sanatorium of Tosari in the Tengger mountains in East Java, at an elevation of 1777 metres above sea-level, found 5,020,400 red blood cells; and at elevations between 2000 and 3000 metres in the Jang mountain the number was 4,380,000. Kohlbrugge seeks to bring the red blood cells into relation with the absolute humidity of the place. Mosso also seems to be somewhat

* While these pages are going through the press, Dr. E. C. Morland furnishes the results obtained by him in Davos :—

| | Red blood cells, per cmm. | Hæmoglobin, per cent. |
|---|---|---|
| 32 men (31 tubercular) | 6,300,000 (min. 5,000,000 max. 7,900,000). | 129 (min. 100, max. 149). |
| 5 women (tubercular) | 5,800,000 (min. 5,300,000, max. 6,100,000). | 117 (min. 114, max. 120). |

Observations made with Thoma-Zeiss hæmacytometer and Sahli's (modified Gowers') hæmometer.

doubtful whether there is an increase of red corpuscles with elevation.

On the whole, however, there is fairly general agreement as to the facts; but as to the interpretation of the facts there is much difference of opinion. Most observers regard the increase as being real and absolute; but some consider that the increase is only in appearance, not in reality. To account for the seeming increase of red blood cells with altitude while denying its reality, has called forth a number of ingenious speculations, which for the most part involve difficulties greater than the difficulty they are required to explain. One theory supposes that the increase of red blood cells is only a relative increase; that the cells are not increased, but that the water of the blood is diminished. One variant of this theory accounts for the loss of water by increased transpiration and evaporation in the drier and more rarefied air of mountains. Another variant supposes that in the mountains the blood plasma or liquid portion is pressed by contraction of the arteries out of the blood-vessels into the tissues.

Another theory ascribes the seeming increase of the red corpuscles to abnormal distribution of the cells.

According to another view, the increase of the red blood cells, in so far as it is real, is due simply to improved health.

Finally, another theory puts down the alleged fact as an error of observation due to a faulty instrument—the Thoma-Zeiss—for counting the blood corpuscles.

One difficulty in accepting the increase as being actual and absolute is the fact that the increase is very rapid, reaching nearly its full amount, as a rule, within some hours after the high altitude has been reached.

Several facts, however, have been ascertained which make the actual and absolute increase of red blood cells with altitude almost certain.

Professor A. Jaquet in Basle and Dr. F. Suter [24] in Davos made a joint investigation in regard to the blood of rabbits. Nine rabbits were sent from Basle to Davos, and, after four months, specimens of their blood were examined. The

animals were then sent back to Basle, and in from twelve to thirty-six hours after their return they were bled to death. Eleven control rabbits were kept in Basle under the same conditions in every respect, except atmospheric conditions, as the rabbits in Davos; and they also were bled to death. The entire quantity of blood was greater by 14·8 per cent in the Davos than in the Basle rabbits. The following table shows the figures:—

| | Basle. | Davos. | Difference per cent. |
|---|---|---|---|
| Blood corpuscles per cmm. defibrinated blood | 5,478,000 | 6,204,000 | 13·25 |
| Hæmoglobin per cent | 13·23 | 14·47 | 9·37 |
| " entire amount in grammes | 12·07 | 14·85 | 23·03 |
| Hæmoglobin in thousandth parts of body weight | 5·39 | 6·59 | 22·26 |
| Quantity of blood (cubic centimetres) | 90·66 | 104·15 | 14·88 |
| Quantity of blood in thousandth parts of body weight | 40·7 | 45·97 | 12·95 |
| Dry residue of blood serum per cent | 6·89 | 7·13 | 3·65 |

A somewhat similar research by Abderhalden at St. Moritz and Basle gave similar results.

Like results also have been obtained from animals living in artificially rarefied air. In a subsequent research Jacquet [25] kept rabbits in Basle in air artificially rarefied to correspond with that at the altitude of Davos. After four weeks their hæmoglobin amounted to 6·7 grammes per kilo. as compared with 5·5 grammes in the control animals, a gain, that is, of 1·2 grammes per kilo. Jaruntowski and Schroeder [26] found an increase of 1,400,000 red blood corpuscles per cubic millimetre when the animal was kept under a glass jar at a barometric pressure of 624 mm. for fifteen days. Regnard [27] kept a guinea-pig for a month under a bell-glass containing air at a pressure of about

520 mm., the air being constantly changed. After this time the animal's blood showed marked increase of absorption power for oxygen, absorbing 21 volumes per cent, while the blood of animals under normal pressure absorbed only from 14 to 17 per cent. Sellier[28] found that air poor in oxygen,—containing 14 volumes per cent instead of the normal 21,—but at the normal pressure, had the same effect as rarefied air in increasing the red blood cells.

No increase of the white corpuscles has been noted in the mountains. The hæmoglobin usually increases in amount; but its increase begins later than that of the red corpuscles, and does not bear any definite proportion to the increase in the red corpuscles. Both of these facts are against the thickening of the blood theory.

One variant of the blood-thickening theory involves the supposition of increased arterial tension. As a matter of fact, however, rarefaction of the air appears to have but little influence on arterial tension; and what influence it has appears to be in the direction of lowered tension.

The increase of red blood cells in the mountains takes place in persons who are in perfect health, and whose blood is normal in the lowlands. The increase occurs rapidly with increased altitude, but does not, as a rule, reach its full amount for ten days or a fortnight.

The improved instrument suggested by Meissen yields figures not materially lower than those furnished by the older instrument.

Various theories have been put forward to account for the increase of red blood cells with altitude. The most usual view is that there is increased formation of blood corpuscles, so that lack of oxygen in the air is compensated for by increased oxygen carrying power in the blood. Another explanation ascribes the abundance of red corpuscles to their diminished destruction owing to lessened metabolism from lack of oxygen. Unfortunately for this theory, metabolism appears to be increased in the mountains, though this is probably owing, not to the diminished pressure, but to the greater cold. Another view is that the increase of

red blood cells, so far as it is a fact, is due not to the rarefied air but to the greater cold, the action of light and of other stimulant agencies. This is Mosso's standpoint.

Objection has been made to the supposition that greater oxygen carrying power of the blood is required in rarefied air. Under an atmospheric pressure corresponding to an altitude of 16,000 feet the same amount of oxygen was found in the blood by Frænkel and Geppert as under normal pressure. Hüfner also found that the amount of oxygen absorbed by hæmoglobin was only 2 per cent less under a pressure of half an atmosphere, and only 4·6 per cent less under one-third of an atmosphere than under a pressure of one atmosphere. Though Hüfner's method and inferences are no longer held valid, the results recently obtained by Bohr and by Krogh are not very dissimilar.

All this, even if true, does not invalidate the supposition. The amount of oxygen that can be absorbed by the blood may be nearly the same in each case; but in rarefied air the absorption takes place more slowly than under normal pressure. By exercise the supply of oxygen in the blood is speedily used up. Under the low pressure the time occupied by inspiration does not suffice to secure the saturation of the hæmoglobin. The breathlessness that follows slight exertion in the mountains is proof of this. Moreover, Loewy, Regnard, and Mosso have found less oxygen in the blood under low pressure than Hüfner's law supposes.

Hence there is no antecedent unlikelihood of an increased formation of red corpuscles to make up for the deficiency of oxygen.

It should be added that the conditions determining the richness of the blood in corpuscles and in hæmoglobin are still imperfectly known. Oliver found that the corpuscles varied in number according to the position of the limb and other influences, such as massage, temperature, and exercise. In obstructive diseases of the heart a great increase in red blood cells has been noted by several observers. In a case of cyanosis, Gibson of Edinburgh found 8,470,000 red corpuscles per cubic millimetre, and 110 per cent of hæmoglobin. He

supposes the increase to be due to diminished metabolism and oxidation, with consequently less wear and tear of corpuscles.

Regnard's experiments on the growth of plants in rarefied air are of great interest. Seeds in constantly renewed air rarefied to a pressure of 410 millimetres—corresponding to the pressure at 4810 metres, the height of Mont Blanc—germinated feebly or not at all. Adult plants in the same conditions gradually died. They became withered and dry, although their roots were in earth that was kept always moist. The same experiment with aquatic plants under water showed no material difference between the plant under normal and under low pressure. Regnard ascribes the result, therefore, rather to increased transpiration and evaporation in rarefied air than to lack of oxygen. Bonnier put plants in their own earth at different altitudes, from sea-level to 2400 metres above the sea. The plants at the higher levels gradually became stunted, but gained in root what they had lost in stem. The epidermis became harder and more impermeable, the stomata infinitely more numerous, and especially the stem became thicker, the palisade or outside leaf cells became longer, and the chlorophyll became infinitely more abundant. Regnard,[29] in summing up his remarks, says: "Bonnier insists strongly on the dark green hue of plants at a high altitude: it is striking, and plants seem to struggle against the rarefaction of the air in the heights by multiplying their organs of nutrition and of reduction just in the same way as we struggle in the same regions against the diminution of oxygen by multiplying our red corpuscles—that is to say, our organs of respiration and of oxidation."

Regnard's mode of experimentation was extremely ingenious; but his account does not show that any provision was made to counteract the fall of temperature caused by rarefaction of the air. Possibly, therefore, cold may have had something to do with the results he obtained.

In contrast with the increased corpuscular richness of the blood in rarefied air stands the fact that divers and other workers in compressed air become anæmic. Gal states that

divers gradually lose in strength, and after a fortnight or three weeks must take a few days' rest in ordinary air to recuperate. Otherwise they become a ready prey to illnesses of all kinds.

Symptoms almost never occur during the stay in compressed air, but come on after decompression, especially after rapid decompression. Pains in the limbs, paralysis of the legs, and even death occur mainly as the result of air emboli formed by gases escaping from the blood on the removal of high pressure.

The noxious effects of compressed air may come on either gradually or suddenly, sometimes beginning the moment decompression is begun, sometimes not appearing till several hours after decompression. The longest interval recorded by Dr. Snell[30] was fourteen hours. The usual interval is from a few minutes to one hour.

The symptoms of gradual and insidious onset are still obscure in origin. It should be borne in mind that oxygen under high tension is absolutely poisonous. Bert showed that a pressure of five to fifteen atmospheres could be borne by animals without injury, provided that the tension of oxygen did not greatly exceed its tension in ordinary air; but when the tension in ordinary air was much raised, even without increased pressure, as, for example, in pure oxygen under a pressure of one atmosphere, toxic symptoms ensued. Such is the intensity of the poisonous action that when the symptoms have reached a certain stage recovery cannot be secured by carefully restoring normal air.

Animals kept in compressed air show diminution of the red blood cells. Experiments of this kind have been made by Sellier, by Regnard, and by Doyon and Morel.[31] These last-named observers found that the red globules had diminished by more than one-third in rabbits that were subjected during twenty-one days to an increasing atmospheric pressure in the work chamber of a bell or caisson used in making a bridge. The highest pressure was a little more than two atmospheres.

The following table gives details :—

Table showing the Influence of Compressed Air on the Number of Red Blood Corpuscles.

| | Fifteen days before. | At the Time of entering the Caisson. | On leaving the Caisson. | Eight days Later. |
|---|---|---|---|---|
| Rabbit 1 . | 5,360,000 | 5,239,000 | 3,115,000 | 5,487,000 |
| Rabbit 2 . | 5,050,000 | 5,301,000 | 3,239,000 | 5,394,000 |
| Control Rabbit | 5,140,000 | 5,394,000 | 5,239,000 | 5,239,000 |

## Physiological Influence of Atmospheric Pressure on the Digestive System

The action of altered air-pressure on the digestive system is indirect, and varies greatly according to circumstances. "Mountain sickness," which commonly occurs in travellers at great elevations, especially at heights over 15,000 feet, will be dealt with presently. At much lower levels many persons, though not affected with acute "mountain sickness," suffer from milder disorders of digestion. Little or no appetite is felt, and dyspepsia in various forms shows itself: flatulence and acidity, with a tendency to constipation, are the most usual troubles, though diarrhœa occasionally occurs. These symptoms may last for a long time—it may be even during the entire residence in the mountains. But, as a rule, the system after a while accommodates itself to the lower pressure. The aerating surface of the lungs is brought fully into play, and the blood, as we have seen, acquires increased oxygen carrying power. When this acclimatisation occurs the digestive functions are performed with efficiency.

Compressed air is said by some observers to sharpen the appetite and to improve digestion; and no doubt it does in cases where there has been poverty in the oxygen supply to the tissues.

## Mountain Sickness

The subject of mountain sickness may be considered here. The symptoms are well known—nausea, and sometimes

actual sickness, palpitation, throbbing of the arteries, rapid breathing, faintness, sense of oppression, headache, giddiness, great prostration, muscular weakness, intense desire to sleep. These symptoms, or some of them, come on, as a rule, more or less suddenly, and at different elevations in different people. They seldom appear before an elevation of 10,000 feet is reached, though they may occur below 6000 feet. The liability to attack is greatly increased by exercise, and especially by fatigue. Some persons escape altogether. The explanation of these symptoms has always been a matter of great interest since they were first described by a traveller in South America—the Jesuit Father, José de Acosta. Mineral emanations and poisonous plants have been supposed by the mountaineers of Peru and of the Himalayas to be at work.

Since Jourdanet in 1861 put forward his theory of anoxhæmia, or lack of oxygen in the blood, the subject has been investigated by many scientific workers. Jourdanet's view was upheld by Paul Bert, and is now very generally accepted.

In 1894 a new view was put forward by Professor Kronecker, Professor of Physiology at Berne. In his admirable work on *Bergkrankheit*, in 1903, he says: "Through very numerous experiments, often unpleasant and dangerous experiments, on myself since 1894, I have arrived at the conviction that, not lack of oxygen in the air, but disturbance of the pulmonary circulation through diminished air-pressure causes the essential phenomena of mountain sickness." Kronecker calls attention to the fact that mountain sickness sometimes occurs at elevations where anoxhæmia cannot be supposed, and where the question of fatigue is excluded. He mentions cases that occurred at 2000 metres, and he observed one himself at 1700 metres. He cites clinical evidence also to show that persons with weak heart or impeded pulmonary circulation suffer very readily at comparatively low altitudes; while persons with extensive damage in the lungs suffer little or no inconvenience if the heart is sound.

The disturbance in the pulmonary circulation of which Kronecker speaks recalls somewhat the old cupping-glass theory of the action of rarefied air. Owing to the chest-wall the lungs are to some extent protected on the outside from alterations in atmospheric pressure. Tigerstedt has recently shown that the systolic pressure in the pulmonary artery in rabbits is usually about 11-20-25 mm. Hg., while the average pressure in the systemic circulation ranges between 50 and 150 mm. Hg. A diminution of from 10 to 30 mm. Hg. in the pressure of the intra-pulmonary air—as in breathing in and out of Waldenburg's spirometer—causes dyspnœa; the suction force of the air being in that case about equal to the propulsive power of the right heart, no force is left to drive on the blood.

In rarefied air the same mechanism, though in less degree, is called into play, the result being the condition described by Von Basch as lung swelling and lung rigidity. The blood passes with difficulty through the lungs to the left heart; the pressure in the pulmonary artery rises and lung swelling takes place through the overfilling of the capillaries of the alveolar cells. This overfilling of the alveolar capillaries causes also lung rigidity. As Von Basch[38] says: "In spite of every effort the patient is unable to adjust his breathing to his air-requirements. When the lung in spite of its rigidity does expand, then on account of its swelling it does not contract again. Cardiac dyspnœa is thus of twofold origin—inspiratory and expiratory—for both inspiration and expiration are mechanically hindered. . . . It is an uninterrupted hunger for air."

In support of his view Kronecker quotes Mosso:[39] "The lungs of animals subjected to the action of rarefied air are slightly œdematous. Their colour is not so pale as usual, it has a reddish-grey tint with dark-bluish spots. In those parts where the colour has remained normal there are spots of lighter hue irregularly distributed. At the surface, and especially at the edge of the pulmonary lobes, there are circumscribed hæmorrhages, ecchymoses, and extravasations of blood of a dark violet colour.

"As the lungs are harder and firmer, they shrink less when the thorax is opened than in an animal in normal physiological conditions. When an incision is made in one of the darker parts of the lung a somewhat frothy liquid exudes.

"The congestion of the lungs and dilatation of the heart sufficiently explain the constant and remarkable diminution found in the vital capacity of all those persons who accompanied me on the Monte Rosa expedition."

That the mechanism described by Kronecker is a factor in the production of mountain sickness, in some cases at least, is extremely probable; but it hardly suffices alone to explain all the facts. Amongst Bert's experiments are some[40] which prove that the tension of the oxygen in the air is a vital consideration. Birds which showed signs of suffering from rarefied air revived immediately upon receiving oxygen, though the pressure still continued to be lowered. In this way Bert succeeded in lowering the pressure of highly oxygenated air to 70·5 mm. without the death of the animal. In another experiment the bird began to suffer in ordinary air at a pressure of 300 mm. At a pressure of 220 mm. the pressure was restored to the normal by means of pure nitrogen, but the bird instead of recovering died almost immediately.

In experimenting on himself, Bert reduced the pressure on one occasion to 408 mm., discomfort always being relieved immediately by the inhalation of oxygen. On another occasion, by breathing oxygen continuously from the moment when discomfort began, he reached the extraordinarily low pressure of 248 mm., corresponding to the height of Mount Everest, 8840 m., and of Glaisher's balloon ascent, 8838 m.

The mechanical theory of mountain sickness hardly explains the great relief given by the inhalation of oxygen. As a matter of clinical experience the inhalation of oxygen, while it gives great and speedy relief in dyspnœa from obstruction in the bronchial tubes, or from diminution of the aerating surface of the lungs, gives remarkably little relief in cardiac dyspnœa.

Amongst the means recommended by Professor Kronecker for the relief of mountain sickness is rest in the horizontal position. Is not this recommendation theoretically at variance with the fact that cardiac dyspnœa is usually aggravated by the horizontal position, owing to the increased pressure in the pulmonary vessels?

Professor Kronecker[41] further says: "I have found relief when, after deep inspiration, I breathe out against the resistance of the voluntarily narrowed air passages (nose and glottis). Thus one can compress the swollen vessels of the lungs." Would not this proceeding be equally likely to help by raising the tension of the oxygen in the air thus compressed, even if there were no swollen blood-vessels?

Another theory of mountain sickness deserves consideration mainly on account of the eminence of its originator. Professor A. Mosso, thinking the ordinarily accepted view of insufficiency of oxygen inadequate to account for mountain sickness, put forward his theory of acapnia or lack of carbonic acid in the blood. With the diminution of atmospheric pressure the carbonic acid in the blood diminishes, and even more rapidly than would be accounted for by Dalton's law. According to Mosso, the carbonic acid normally present in the blood acts as a stimulus to the medulla oblongata in regulating the respiratory movements. He therefore regards the diminution of the $CO_2$ in the blood as the withdrawal of a stimulus, with consequent depression of the nerve centres. Hence the whole group of symptoms in mountain sickness; also the loss of voice and difficulty in swallowing occasionally noted, besides irregular rhythm and sometimes during repose diminished frequency of the breathing.

Mosso's experiments and reasoning are decidedly unconvincing. Kronecker points out that holding the breath neither prevents nor cures mountain sickness, and that the less frequent breathing at night should, according to the theory, be helpful; but the contrary is the case. All evidence shows that the symptoms are relieved by oxygen.

## Influence of Atmospheric Pressure on the Nervous System

The action of diminished air pressure on the nervous system also is indirect. If the oxidising agencies of the body fail to respond to the demand, owing either to diminished supply of oxygen or to increased demand for tissue change through the increased cold of a high altitude, functional activity is lowered. The nervous system suffers from increased irritability, but diminished power. Sleeplessness is frequent, and dreams cause much discomfort. Emotional excitability, with incapacity for mental work, is not uncommon amongst persons whose intra-organic changes cannot quite keep pace with the requirements of the system.

When the organs respond to the increased demand, the digestive, nervous, and muscular systems all benefit by the more active nutrition. Appetite is good, digestion comfortable. The mental processes are performed with vigour, the spirits are lively, exercise is a pleasure, and sleep sound.

De Saussure,[43] speaking of his stay with his son from 3rd to 19th July 1788 on Col du Geant, at an elevation of 3360 metres (11,020 feet), says: "It seemed to me that in general the nervous system was more irritable; that we were more liable to impatience and to outbursts of anger; we were distinctly more thirsty, hunger was more urgent and imperious, the digestive functions were more readily performed than in the plain. Besides, it seemed to my son and to me that in our physical observations we worked with distinctly freer and more active spirit, and that the mind was less easily fatigued, I will even say more inventive than in the plain; and I trust that our readers will find the proof of it in the account of our doings during these seventeen days."

At very great elevations balloonists and mountaineers have remarked noises in the head and giddiness, impairment of the senses, sight, hearing, and touch, of dulness of the intellectual faculties, of slowness in mental perception, of difficulty in making simple calculations, and of a strong

desire to sleep. De Saussure records his experience on the summit of Mont Blanc in August 1787, at an elevation of 15,700 feet. After having reached the summit, he says: "It was necessary now to make the observations and experiments which alone gave any value to the expedition; and I feared very much to be able to do only a small part of what I had planned. For I had already found, even on the plateau where we had slept, that every observation carefully made in this rarefied air fatigues, because without thinking one holds one's breath; and as it is necessary to make up for the rarity of the air by the frequency of the inspirations, this causes a sensible discomfort. I was obliged to rest and breathe after having observed any instrument, as after having made a rapid ascent." Before descending, he says: "Although I had not lost a single moment I had not been able to make in four hours and a half all the observations that I had frequently done in less than three hours at the seaside. But I preserved the well-founded hope of accomplishing on the Col du Geant what I had not done, and what probably never will be done, on Mont Blanc." Boussingault's remarks, quoted by Hirsch,[42] are interesting in this connection: "After looking at the bustle of traffic in towns like Bogota, Micuipampa, Potosi, and such like, at elevations of 8000 to 12,000 feet, after witnessing the strength and the marvellous skill of the toreadors in the bull-fights at Quito, 9000 feet above the sea-level, after seeing young and delicate girls dancing a whole night at places almost as high as Mont Blanc, on which the celebrated Saussure had hardly strength enough to use his instruments of observation and his hardy guides fell down in a swoon as they proceeded to dig a hole in the snow; when we remember, finally, that a famous battle, that of Pichincha, was won almost in the altitude of Monte Rosa, I think you will agree with me that man can become adapted to breathing the rarefied air of the very highest mountains."

Robertson,[44] the French physicist, who made a balloon ascent on July 18, 1803, speaking of the mental and bodily apathy of himself and of his companion when the

barometric column was at 12 inches—an elevation of about 7170 metres (23,517 feet)—says: "At this elevated point our condition was one of indifference; there the physicist is no longer alive to the glow and to the passion of discovery; the danger arising from the smallest negligence hardly occupies him. Only with the help of a little bracing wine does he manage to regain some interests of intelligence and of volition." On another occasion he says: "When one reaches the elevation of 3600 toises (6920 metres, or 22,690 feet) one yields gradually and in an insensible manner to a lethargic sleep—the mental faculties becoming extinguished long before the physical. At first one has neither memory for the present nor care for the future; one forgets the attention required by the aerostat. Soon a gradual, sweet sleep, felt to be irresistible, overcomes the limbs and holds the aeronaut in complete asphyxia, which if prolonged would no doubt be fatal." Then, referring to the excursion just mentioned, he says: "The sky appeared brown, the sun was without brilliancy; one could look steadily at him without being dazzled. . . . We yielded to sleep. . . . We both awoke from this slumber at the same time, and suddenly, without being able to say what had taken place, except that there had been a solution of continuity in our ideas."

In the remarkable balloon ascent by Glaisher and Coxwell on September 5, 1862, a height of 29,000 feet was reached before Mr. Glaisher lost consciousness, while even then Mr. Coxwell retained his senses, though he almost lost the power of movement.[45]

Bert tells us that in one of his experiments in his air-chamber, when the pressure was 420 mm. (16½ inches), corresponding to the pressure on the top of Mont Blanc, he was surprised not to be able to multiply 28, the number of his heart-beats in a third of a minute, by 3. He was obliged to content himself with writing the figures in his note-book.[46]

In Professor Ugolino Mosso,[47] A. Mosso's brother, artificial mountain sickness began when the rarefaction was

indicated by a barometric height of 31 cm. (= 7141 metres). The mental faculties then became blunted. He had difficulty in reading the seconds of his watch; and twice he was unable to count his pulse in spite of the concentration of his attention. At an artificial altitude of 7400 metres in the pneumatic chamber he felt about the same degree of indisposition as at the Gnifetti Hut at 3620 metres.

M. Croce-Spinelli tells the same story in recounting the experience of himself and Sivel in Bert's air-chamber in preparation for the high balloon ascents, which were soon to have a fatal termination. When the pressure was reduced to about 48 cm. ($18\frac{7}{8}$ inches), corresponding to 3659 metres, a sense of oppression was first noticed. He says: "I become more indolent. . . . Our mental energy has not been otherwise diminished, for we are in good spirits and talkative. Below 35 cm. ($13\frac{3}{4}$ inches) my sight had become dim; but after the inhalation of oxygen became distinctly clearer. I saw light after having seen darkness; the interior of the chamber appeared suddenly to become brighter." About a year later, on April 15, 1875, these devotees of science were to perish in the highest realms of air attainable by man, to die asphyxiated in the subtle air, though only a little way above the deepest layers of the atmospheric ocean which bathes this planet.

The mental and physical depression described in the foregoing paragraphs occurred only at enormous elevations, not likely to be resorted to therapeutically. But this lowering of all the vital forces occurred in men of robust frame and in good health. The point to be borne in mind by the physician is that the same phenomena may arise at a much lower level in persons with feeble heart or inefficient lungs. Croce-Spinelli, who was of lymphatic, nervous type and subject to bronchitis, notes that he suffered from the rarefaction of the air long before his companion Sivel. De Saussure remarks:[48] "One curious fact I have observed is that for some individuals there are definitely marked limits where the rarity of the air becomes for them absolutely insupportable. I have often taken with me peasants other-

wise very robust, who at a certain height became incommoded to such a degree as to be quite unable to ascend further; and repose, cordials, and the liveliest desire to reach the summit of the mountain were alike unavailing to enable them to pass that limit. They were seized, some with palpitation, some with vomiting, some with panting, and some with a violent fever; and all these accidents disappeared the moment they breathed a denser air. I have seen some persons, though rarely, whom these indispositions obliged to stop at 800 toises (5040 feet) over sea-level; others at 1200 (7560 feet); several at 1500 (9450 feet) or 1600 (10,080 feet); as for me, like most inhabitants of the Alps, I begin to be distinctly affected only at 1900 toises (11,970 feet); but above this limit the most expert begin to suffer when they move a little hastily."

A febrile state is noticed by De Saussure in mountaineers as liable to occur in high ascents; but the body temperature when taken has, as a rule, been normal or subnormal.

De Saussure [49] finds that persons affected with mountain sickness showed a greater difference between the pulse rate at a high and at a low level, than did persons who kept well. He ascribed the trouble "in part to a kind of fever produced by the frequency of the respiration, which quickens the circulation of the blood." Meyen, speaking of his experience (April 1831) on the summit of Arequipa in Peru, at an elevation of 18,490 feet (5640 metres), says: [50] "The symptoms of a nervous or feverish state to which we had been a prey during the entire ascent gradually increased. . . . This febrile state increases with exertion and also under the influence of the dry, cold, strong winds so common in the Cordillera."

As the symptoms pass off at once on lying down, actual pyrexia can hardly be present. This state of "nervous excitement, simulating fever, is probably accounted for by the more rapid action of lungs and heart, acting reflexly on the nervous system and stirring up associated feelings.

The tonic, bracing, or stimulating influence of places at a habitable elevation is no doubt mainly due to the increased

metabolism and to the stimulus of the colder and drier air acting both on the external surface and on the mucous membrane of the bronchial tubes and lungs. The brighter light is also probably an assisting agent. The "over-stimulation," or nervous excitement, sometimes spoken of in elevated health resorts, arises no doubt partly from these causes and partly from the more rapid action of heart and lungs.

### Influence of Atmospheric Pressure on the Skin

A change in atmospheric pressure modifies two sets of conditions which largely influence the state of the skin. It disturbs the balance of the circulation and it alters the temperature of the air, thus bringing about other degrees of humidity, translucency, and diathermancy. The splitting of the skin and the bleeding that take place from the cracks as well as from the eyes, nose, and lips under greatly diminished pressure, are traceable partly to dessication of the surface and partly to venous engorgement from deficient oxygenation. Increased pressure, we saw, gives rise to surface anæmia.

The dryness of the skin at great altitudes is due partly to the smaller amount of water-vapour in the air, and partly to the greater force of evaporation under diminished pressure. Persons troubled with moist skin are usually benefited by a stay in the mountains. Night perspirations commonly diminish or disappear.

The skin, when habitually damp, fails to serve its purpose of protecting the organs within from chill, and leaves an open door to most of those diseases that arise from "cold." The intense cold of the Alps being dry, is well borne by many persons who suffer from the mild cold of a damp English winter.

### Influence of Atmospheric Pressure on the Genito-Urinary System

The influence of diminished atmospheric pressure on the urine is not yet definitely settled. In mountain ascents

the severe exercise causes an increased loss of water by the skin with diminution of the urinary secretion; but in the absence of exercise an augmented flow is commonly remarked, due no doubt to the smaller loss by the skin in dryer and colder air. In compressed air the urine is said to become more abundant. The amount of urea, according to Bert's experiments, was diminished in rarified air, and increased in air compressed up to three atmospheres. Most other observers, however, have found the quantity of urea practically unaffected by change of pressure.

In considering the influence of temperature (p. 94), we saw that menstruation comes on early in hot climates, late in cold ones, and that in girls who had begun to menstruate in England, the flow not infrequently diminishes or ceases when they go to a high Alpine resort for the winter. The function is also, as a rule, attended with less pain. The normal condition reappears when life in the lowlands is resumed. These results are probably due to changes in temperature rather than to changes in pressure.

### Physiological Influence of Wind

The physiological action of wind depends mainly on its power of abstracting heat, but also to some extent on its mechanical influence.

In removing heat from the body, wind is much more powerful than still air of the same temperature. The air in contact with the skin being removed as fast as it is warmed and being replaced by other cool particles, the chilling effects are greater. A special influence may be attributed to wind by virtue of its tendency to remove heat unevenly from the surface of the body. In other words, it attacks unprotected parts with special force.

The following table from Rubner [51] shows the influence of cold wind in augmenting the excretion of carbonic dioxide:—

Excretion of $CO_2$ in Grammes per hour in Man weighing 58 kilos. Medium Humidity.

| Temperature. | No Wind. | Wind. 1 metre per second. | Wind. 8 metres per second. | Wind. 16 metres per second. |
|---|---|---|---|---|
| °C. 2 | 29·8 | ... | ... | ... |
| 10-15 | 25·1 | 28·3 | 30·0 | ... |
| 15-20 | 24·1 | ... | 30·1 | ... |
| 20-25 | 25·0 | ... | 28·0 | ... |
| 25-30 | 25·3 | 22·2 | 24·4 | ... |
| 30-35 | 23·7 | ... | 21·6 | ... |
| 35-40 | 21·2 | 22·2 | 22·1 | 23·1 |

Apart from their physiological action, winds have an important hygienic function: they carry away the impurities that are constantly thrown into the atmosphere, and replace them by purer streams from elsewhere. Sometimes, however, their agency is the reverse of healthful. Not merely do they cause, in many instances, the spread of epidemics in a given direction, but certain winds seem to be endowed with noxious qualities incapable of being accounted for by peculiarities in temperature, humidity, or force, and appear due to some special influence. Professor Bain [52] makes an interesting speculation on the subject: "The north-east wind is known to be specially injurious to a great many persons. Let the inquiry be — What circumstances or qualities is this owing to? By a mental analysis, we can distinguish various qualities in winds — the degree of violence, the temperature, the humidity or dryness, the electricity, and the ozone. We then refer to the actual instances to see if some one mode of any of these qualities uniformly accompanies this particular wind. Now we find that as regards violence, easterly winds are generally feeble and steady, but on particular occasions they are stormy hence we cannot attribute their noxiousness to the intensity of the current. Again, while often cold, they are sometimes comparatively warm; and although they are more

disagreeable when cold, yet they do not lose their character by being raised in temperature; so that the bad feature is not coldness. Neither is there one uniform degree of moisture; they are sometimes wet and sometimes dry. Again, as to electricity, there is no constant electric charge connected with them, either positive or negative, feeble or intense, the electric tension of the atmosphere generally rises as the temperature falls. Further, as respects ozone, they have undoubtedly less of this element than the south-west winds; yet an easterly wind at the seashore has more ozone than a westerly wind in the heart of a town. It would thus appear that the depressing effect cannot be assigned to any one of these five circumstances. When, however, we investigate closely the conditions of the north-westerly current, we find that it blows from the Pole towards the Equator, and is for several thousand miles close upon the surface of the ground; whereas the south-west wind coming from the Equator descends upon us from a height. Now, in the course of this long contact with the ground, a great number of impure elements, gaseous effluvia, fine dust, microscopic germs, may be caught up, and may remain suspended in the lower stratum breathed by us. On this point alone, so far as we can at present discover, the agreement is constant and uniform."

The physiological action of wind is for the most part referable to the altered heat-removing conditions which vary with every change in temperature and humidity.

The enervating effect of the Föhn wind, so well known in the Alps, is easily explicable in accordance with the principles laid down in the discussion of temperature. The Föhn, as already explained, is a south wind which, in sweeping northwards over the Alpine chain, deposits its moisture on the southern declivities of the range, and descends dry and warm on the northern slopes. If the heat-producing mechanism of the body had been set for an outside temperature of from 10 to 20 degrees below freezing-point, a rise in the temperature to freezing-point or 10 degrees over it causes a sense of oppression.

The Föhn wind, though dried in crossing the mountains, may take up moisture again from the snow which it melts and evaporates. During the prevalence of the Föhn a haze in the atmosphere is not uncommon, though at night the sky is usually clear.

The Mistral, so much dreaded on the Riviera, is a cold wind sweeping down from the north through gaps in the mountain range. The chilling effect of this wind is intensified by its velocity.

The hot winds of the desert, the scirocco, and the chamsin have a physiological action more or less resembling that of the Föhn.

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# CHAPTER XI

## LIGHT

### Influence of Light

Under the influence of light the green cells of plants break up the carbonic acid presented to them, keeping the carbon and setting free the oxygen. Without this first step in the building up of food, the storing of chemical energy cannot take place. The first step is an indispensable process in the formation of starch, in the subsequent development of albumen, and hence in the nutrition of animal life. Without light there could be no vegetable life. Light is thus a form of energy representing one stage in the transformations undergone by Force in its circulation through the kingdom of Nature. The vibrations of light are converted into chemical energy by the chlorophyll of plants.

Owing to the different properties of the different portions of the spectrum, the most refrangible rays — the blue, violet, and ultra-violet—are termed the chemical rays; the least refrangible—the red and ultra-red—are termed the heat rays; and the intermediate—the yellow and green—are termed the light rays.

Yellow light is especially active in causing chlorophyll to split up carbonic acid into its component parts. The violet rays, on the other hand, are inactive in this respect. This has been shown by direct experiment. In a mixture of carbonic acid and atmospheric air, with green plants in a cylinder exposed to yellow light, the carbonic acid

diminishes and finally disappears, while the oxygen becomes more abundant. In the dark or exposed to violet light the mixture of gases remains unchanged. M. Flammarion recently made some observations on the growth of plants exposed to light of various colours, the meteorological conditions being in other respects alike. The plants were placed in glass boxes uncoloured and coloured respectively red, green, and blue. After three months the plants exposed to the blue light had not grown at all, while those exposed to the red had grown to fifteen times their original height—a greater increase than had taken place in the plants exposed to white light, though in both cases the amount of red light received was the same. Hence it would seem that blue light actually retards the growth of plants.

The evidence, however, is not uniform as to the influence of the various rays. Pleasonton found that plants and animals grew more rapidly when exposed to violet light. Violet and blue rays hasten the hatching of flies' eggs (J. Beclard) and of frogs' eggs (E. Yung) more than do red, yellow, or green rays. The violet and blue rays are also those which most stimulate heliotropism and the movements of leaves.

Paul Bert found that red and yellow light were without influence on the chromatophores or pigment cells of chameleons, while blue and violet light act strongly on them. He noticed further that if one half of the chameleon was exposed to red light and the other half to blue light, the portion under the blue turned black speedily, while the portion under the red long remained light in colour.

It is now definitely known by direct experiment that the pigmentation of the skin and the erythema produced by sunlight are due, not to the heat rays, but to the chemical rays, chiefly the ultra-violet.

The irritation of the skin caused by powerful electric light was supposed by Charcot in 1859 to be due, not to the heat, but to the chemical rays, and to be identical with sunburn. In 1889 Widmark showed that this supposition

was correct. Experimenting with an electric arc lamp of 1200 candle-power, he found that under the action of all rays, with the exception of the ultra-violet, the skin remained unchanged; and that under the action of all rays, except the heat rays, the characteristic inflammation of the skin appeared.

Acting on the knowledge of the irritant action of the chemical rays on the skin, Professor Finsen [1] of Copenhagen inaugurated the treatment of smallpox by red light—that is, by light from which the chemical rays are excluded. This treatment, when carefully carried out, has, according to Finsen, given remarkable results. When it is begun at an early stage of the disease and rigidly pursued throughout, Finsen says the vesicles, even in severe confluent cases, never become pustular, the suppurative fever is averted, and the vesicles finally dry up without leaving any loss of substance. These results are obtained only when the chemical rays are absolutely excluded without intermission from an early stage of the disease. No claim is made for lowered mortality from this method, but merely for some diminution in the severity of the attack and the avoidance of subsequent disfigurement.

In the *Lancet* of July 30, 1904, there is an important paper by Drs. Ricketts and Byles on the "Red-Light Treatment of Smallpox." After carefully trying it in thirteen cases they say: "We think that we have succeeded in showing, not only that the case for this method of treatment is not proved, but that no serious evidence has been advanced in favour of it. . . . We thought that it had an unfavourable effect on the general condition of the patient. The tendency to mental symptoms (delirium, headache, restlessness, etc.) seemed more marked. The suppurative fever, too, appeared to us to range higher than might have been expected. It is true that we found the patients did well in respect of affections of the eye. That was to be expected. But, on the other hand, we thought that they had more than their fair share of the other septic sequelæ of smallpox." Ricketts and Byles cite Brayton of Indian-

opolis, who treated 300 patients by the red-light method, and an equal number of patients in wards lighted by the ordinary methods. "He found that in no respects did the patients under the red-light treatment do any better than the others. Suppuration, fever, scarring, and death were all unchecked."

Finsen, in a paper published after his death, the last paper he ever wrote, sharply criticised the observations of Ricketts and Byles. Other observers have joined in the discussion, and the question is still unsettled.

Frogs' eggs and tadpoles develop more rapidly when exposed to light than in the dark (Moleschott, Fubini, and others). That light causes animals to absorb a greater quantity of oxygen and to give out a greater quantity of carbonic acid was first observed by Moleschott; and his results have been confirmed by subsequent investigators. Platen [2] found that young dogs whose eyes were exposed to light took up 16 per cent more oxygen and excreted 14 per cent more carbonic acid than when their eyes were protected from light. It should be remembered that stimulation of other nerves of sense, the nerve of hearing, for example, by music, has a like effect, as indeed has any stimulation of the nervous system, whether by joy or terror.

A table drawn up by Perrier [3] shows the influence of the various rays of the spectrum on the amount of carbonic acid formed in a given time :—

| Animal. | Darkness. | Red. | White. | Violet. |
|---|---|---|---|---|
| Frog . . . | 100 | 100·5 | 112 | 115 |
| Sparrow, canary . | 100 | 128 | 142 | 139 |
| Rat (surmulot) . | 100 | 111 | 137 | 140 |

He adds: "It can be understood that in well-nourished animals this greater stimulation has a beneficial effect in augmenting the activity of the vital processes. . . . It is also quite comprehensible that animals deprived of nourishment die sooner in violet than in red light."

It has been found that sunlight in a few minutes kills tubercle bacilli and certain other low forms of life.

Downes and Blunt[4] pointed out in 1877 that diffused daylight and, still more, direct sunlight kills putrefactive bacteria. They further showed that this result is due, not to the heat rays, but to the blue, violet, and ultra-violet rays. These observations have been abundantly confirmed by subsequent investigators. Micro-organisms show the same individual differences in resistance to the action of light as they do to other antiseptic agents. The erythrobacteria even seek the light, and flourish in it. According to Dieudonné[5] the anti-bacterial influence of light is to be ascribed, in part at least, to the development of peroxide of hydrogen. W. Kruse concluded that the intensity of the action of light on micro-organisms depends on the proportion of oxygen present. The researches of Valdemar Bie,[6] however, seem to show that the bactericidal action of light is independent of the formation of oxygen.

The action of light on the tubercle bacillus led Finsen[7] to treat lupus by means of the chemical rays of the spectrum, and with very great success. That these rays pass through the skin has been shown experimentally. By means of a trocar Godneff placed small hermetically-sealed glass tubes filled with chloride of silver under the skin of dogs and cats. Some of the animals were placed in the dark, the others in direct sunlight. The tubes were removed after an hour, and the silver salt was found to have turned quite black in those cases where the animals had been exposed to the sun, but not in the others. An experiment by Finsen shows that these rays pass readily through the tissues, but that blood arrests them. On one side of a man's ear Finsen placed sensitised photographic paper. On the other side of the ear he caused blue-violet rays to fall. After five minutes the paper was still unaffected. Then he pressed the ear between two glass plates till it was white (bloodless). Within twenty seconds the paper was coloured, and in five minutes quite black. In the treatment of lupus by this method, therefore,

the affected part must be under pressure to keep it bloodless.

The success of the light treatment on lupus has led to the hope that tubercle in the deeper tissues might be amenable to the same method. The experimental evidence up to the present, however, is not very promising. The difficulty is that the bactericidal rays—the blue, violet, and ultra-violet—penetrate the tissues only to a very slight extent. Gunni Busck[8] made some careful experiments in 1902 to determine the comparative power of the various rays of the spectrum to pass through animal tissues. Using an arc lamp of from 60 to 70 ampères, he found that the penetrative power of the various rays through the blood-filled ear of a rabbit, and seemingly through most animal tissues, rises from the extreme ultra-violet, where the penetrative power is extraordinarily low, through the coloured portion of the spectrum, and into the ultra-red, where the maximum penetrative power is to be found. In the outer portion of the ultra-red the penetrative power again falls.

The relative percentage of penetration power of the various rays—ultra-red, red, orange, yellow, green, blue, indigo, violet, ultra-violet—is as follows:—

| Ultra-Red. | R. O. Y. Gr. B. I. V. | Ultra-Violet. |
|---|---|---|
| <5 to 23 >28 | 22 1> | |

These figures are intended to show that the red-yellow rays pass through animal tissues twenty-two times better than do the blue-violet rays; the inner ultra-red rays twenty-eight times better, and so on. The figures do not represent absolute values.

In another form of experiment Busck found that when light from a 70 ampère lamp, the rays of which were made parallel by a Finsen's concentration apparatus, was thrown on one side of the naturally blood-filled ear of a rabbit, the

whole of the coloured portion of the spectrum was represented in the rays that passed through. When two ears were in front of the light the blue-violet rays were lost, while the green, yellow, and red passed through. With three ears the green rays disappeared; and with four ears the red only reached the other side.

In another experiment Busck observed that concentrated red light from a 70 ampère arc lamp was faintly discernible through 5·1 cm. thickness of the forearm.

The bactericidal influence of the various portions of the spectrum has been investigated by many observers, especially by Finsen's pupils. Valdemar Bie,[9] used an electric arc lamp of 35 ampères and 45 volts (about 6000 candle-power). Concentrating the light by Finsen's apparatus, he passed it through various coloured solutions, thus keeping back different portions of the spectrum in turn. The influence of various portions of the spectrum on cultures of *bacillus prodigiosus* is shown in the following table. The table shows also the fluids through which the light was filtered. The difference between the action of quinine sulphate solution and the action of nickel sulphate solution is to be noted. Both of these solutions allow rays with wave lengths from 760 to 418 $\mu\mu$ * to pass; but the quinine sulphate solution interferes only slightly with wave lengths from 426 to 418 $\mu\mu$, while nickel sulphate solution weakens the rays considerably.

* $\mu$, a micron = $\frac{1}{1000}$ millimetre = $\frac{1}{25,400}$ inch; $\mu\mu$, a micromicron *or* millimicron = $\frac{1}{1,000,000}$ millimetre.

[Table

| *a* Name of the Fluid. | *b* Extent of Spectrum in Wave Lengths. | *c* Colour of Rays. | *d* Growth is arrested by Action in | *e* The Bacteria are killed by Action in |
|---|---|---|---|---|
| I. Distilled water . | From 760 $\mu\mu$ to 350-300 $\mu\mu$ | All components of the visible spectrum | $\frac{1}{4}$ minute | 35 minutes. |
| II. $1\frac{1}{2}$ per cent solution of quinine sulphate | 760 $\mu\mu$-418 $\mu\mu$ | Red, orange, yellow, green, blue, and a little violet. The band 426-418 strong | $\frac{3}{4}$ minute | 80 minutes. |
| III. 5 per cent solution of nickel sulphate | 760 $\mu\mu$-418 $\mu\mu$ | Red, orange, yellow, green, blue, and a little violet. The band 426-418 weak | 3 minutes | 2 hours. |
| IV. $1\frac{1}{2}$ per cent solution of potash monochromate | 760 $\mu\mu$-499 $\mu\mu$ | Red, orange, yellow, and almost all the green | 6 minutes | 4 hours. |
| V. $1\frac{1}{2}$ per cent solution of potash bichromate | 760 $\mu\mu$-541 $\mu\mu$ | Red, orange, and almost all the yellow | 18 minutes | about 9 hours. |
| VI. $\frac{1}{7}$ per cent solution of fuchsin | 760 $\mu\mu$-656 $\mu\mu$ | Red | 90 minutes | Undetermined. |

The results of this table are put in comparative form by Gunni Busck :—

| Name of Fluid. | Extent of Spectrum in Wave Lengths. | Growth arresting Action of Rays. | Bactericidal Action of Rays. |
|---|---|---|---|
| Distilled water . . | From 760 $\mu\mu$ to 350-300 $\mu\mu$ | 360 | $77\frac{1}{7}$ |
| $1\frac{1}{2}$ per cent quinine sulphate solution | From 760 $\mu\mu$ to 418 $\mu\mu$ | 120 | $33\frac{3}{4}$ |
| 5 per cent nickel sulphate solution | From 760 $\mu\mu$ to 418 $\mu\mu$ | 30 | $22\frac{1}{2}$ |
| $1\frac{1}{2}$ per cent potash monochromate solution | From 760 $\mu\mu$ to 499 $\mu\mu$ | 15 | $11\frac{1}{4}$ |
| $1\frac{1}{2}$ per cent potash bichromate solution | From 760 $\mu\mu$ to 541 $\mu\mu$ | 5 | 5 |
| $\frac{1}{7}$ per cent fuchsin solution | From 760 $\mu\mu$ to 656 $\mu\mu$ | 1 | Undetermined |

According to Bie, all the rays of the spectrum from red on, restrain the development of bacteria. Whether the red rays can kill bacteria is unproved; but the other portions of the spectrum have this power. The bactericidal action

of the various rays increases almost evenly with the index of refrangibility of the rays up to the beginning of the violet, where there is a marked increase.

In a later research Bie[10] examined the bactericidal action of the ultra-violet rays. In his experiments the action of the ultra-violet rays, which have a wave length between 200 $\mu\mu$ and 295 $\mu\mu$, was ten to twelve times as great as the action of all the rest of the spectrum from the beginning of the red (about 760 $\mu\mu$) to the beginning of the portion of the spectrum in question (295 $\mu\mu$).

The absence of bactericidal action in the rays that can pierce the tissues does not necessarily mean that the local employment of light is useless in the treatment of deep-seated tubercle—tubercle in the lungs, abdomen, or joints. Whether the bacillus tuberculosis thrives in the tissues or not, depends on the relative power or vitality of the bacillus and of the tissues. The rays that pierce the tissues, though they may be unable to kill the bacillus, may weaken it enough to turn the scale in favour of the tissues. Against this view is the fact that a very small percentage of rays even from powerful concentrated red light reached a depth of more than two or three centimetres, and if when strong and highly concentrated they have little action, they cannot have much when feeble and few.

Dreyer[11] recently made a remarkable investigation concerning the power of certain substances to "sensitise" infusoria or render them less resistant to light. Work in the same direction had previously been done by Danielsohn, Ullmann, Jacobsen, Raab, and Ledoux-Lebard. Fluorescent substances, such as acridin, quinine, and eosin, were found to have the property in question, which was thought to depend on the fluorescence. Dreyer obtained results which may have far-reaching consequences. He found that infusoria—nassula—in a 1 in 8000 solution of erythrosin, while not impaired in vitality or more sensitive to chemical agencies, were extraordinarily sensitive to light, and even to those portions of the spectrum to which they are ordinarily insensitive. The research was then extended to micro-organisms, and with

similar results. Cultures of *bacillus prodigiosus* in agar and in agar mixed with $\frac{1}{5000}$ part of erythrosin were exposed to various portions of the spectrum. The following table shows the results :—

| Light Filter. | Rays allowed to Pass. | Time till Death of B. Prodigiosus. | |
|---|---|---|---|
| | | Sensitised. | Normal. |
| Rock crystal . . . | All rays . . . . | 80 seconds | 80 seconds |
| Clear glass with distilled water | All visible rays of the spectrum | 10 minutes | 10 minutes |
| 5 per cent nickel sulphate solution | Red, orange, yellow, green, blue and some violet rays | 10 minutes | 35 minutes |
| Blue glass. . . . | Blue, violet, some yellow and green, and many red rays | 10 minutes | 20 minutes |
| 3 per cent ammoniacal solution of copper sulphate | Blue-violet, and blue ; also some yellow-green rays, but fewer than with blue glass | 12 minutes | 35 minutes |
| 5 per cent potash monochromate solution | Red, orange, yellow, and yellow-green | 15 minutes | More than 4 hours |
| 5 per cent potash bichromate solution | Red, orange, and yellow | 25 minutes | More than 9 hours |

Dreyer concludes that micro-organisms and animal tissues may by means of certain sensitising agents, be made as sensitive to the otherwise inactive but relatively penetrating yellow and green rays as they commonly are to the active but non-penetrating chemical rays, or even that they may be made sensitive in a higher degree.

The explanation of the fact is not clear. The property is not due to fluorescence: some substances which are strongly fluorescent (esculin and fluorescein) sensitise little or not at all; and some substances which are not fluorescent do sensitise (cyanin).

There is a certain amount of empirical evidence that "sun baths" have a favourable influence on deep-seated tubercle. At Veldes in Austria the sun and air cure—a clothless system—has been developed by A. Rikli, a Swiss layman. The system is often beneficial, but is not unattended with risk. Some cases under my observation

improved remarkably from general exposure of the body surface to direct sunlight for a couple of hours daily. The influence is probably for the most part, if not altogether, indirect, through the general health.

The influence of light on the formation of hæmoglobin and of red blood cells has been investigated by various observers, but not with uniform results. A careful research by Dr. Marti,[12] under Professor Kronecker's guidance, shows that light, or in fact any mild stimulation of the skin, increases the number of red blood cells ; while either absence of light or violent irritation attended with inflammation, diminishes the number.

Finsen[13] quotes from Eder the following interesting table, which shows the different proportion of different rays in light from different sources. The intensity of light of Frauenhofer's line D is placed at 100 :—

| | Light-power in Different Portions of the Spectrum. | | | | Total Light-power in Normal Candle-power. |
|---|---|---|---|---|---|
| | C (Red). | D (Yellow). | b′ | F½ G (Blue). | |
| Normal candle-power | 73 | 100 | 104 | 134 | 1 |
| Gas lamp . . | 74 | 100 | 103 | 125 | 16 |
| Limelight . . | 59 | 100 | 113 | 285 | 90 |
| Electric arc light . | 61 | 100 | 121 | 735 | 362 |
| Magnesium light . | 50 | 100 | 223 | 1129 | 215 |
| Moonlight . . | 87 | 100 | 155 | 363 | 204 |
| Sunlight . . . | 45 | 100 | 250 | 2971 | 70,000 |

The electric light here spoken of is that produced by the arc lamp. The light supplied by the incandescent film contains comparatively few chemical rays. Even in the arc lamp the proportion of the ultra-violet rays varies according to the chemical composition and diameter of the carbons and the strength of the current.

From the foregoing account it will be seen that light has a powerful physiological influence; though our knowledge of the subject is still extremely imperfect. The good

influence of many health resorts is probably in large part due to their abundant sunshine. One of Nansen's Polar Expedition party makes the following statement: "The last winter in the ice was simply awful. We had our fill of the darkness. We got sleepy and indifferent, and shaky on our legs. We were not ill, but weak and dead beat, and the doctor was anxious about our brains. When the day came with the sun, it was like a resurrection for us all. We were electrified when we saw him. Nobody knows how fine the sun looks but those who have been six months in darkness. Then we came to strength again."

## Electricity

At present we have practically no knowledge of the influence, if any, of the varying states of electric tension of the atmosphere on the animal organism. There is, however, ground for thinking that atmospheric electricity exerts a by no means unimportant physiological action, which in the course of years will probably be understood.

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# CHAPTER XII

## POINTS DETERMINING THE REACTION OF THE ORGANISM TO VARIOUS CLIMATIC INFLUENCES

We have examined the physiological influence of the factors of climate considered independently: that is, without reference either to their joint action or to the reaction of the organism. The reaction of the organism will now be considered; and in a later section the influences of the climatic factors in combination, as in the various types of climate, will be examined.

The most fundamental point in the action of climate is its influence on tissue change. From what we have seen, tissue change is high or low according to the demand, provided the supply of oxygen be sufficient. Only in a subordinate degree is the process influenced by variations in the tension of oxygen ordinarily met with.

The demand depends on the surrounding temperature, as well as on the wind, moisture, and all other circumstances affecting the abstraction of heat. Even when these conditions are in all respects identical, their action on different people will vary according to the peculiarities of the person. For example, the anæmic, whose blood corpuscles can hardly carry oxygen enough, would have their tissue change stimulated by increase in oxygen, which to the full-blooded would be without influence. A person whose skin is always dry and a person whose skin tends to be moist are differently affected by moisture in the air.

This different reaction of different individuals to the same external conditions is of great practical importance;

and we must seek to determine the circumstances on which it depends, so that we may gauge or estimate beforehand how the organism will respond to a considerably increased or diminished heat demand. The digestive, circulatory, respiratory, muscular, nervous, and integumentary systems all influence the result.

Abundance of red blood corpuscles is a condition favourable to tissue change. Not merely must the blood be in good condition, but the heart and vessels also must act efficiently. A weakly acting heart fails to distribute the blood satisfactorily throughout the body, and thus the tissues do not receive a proper supply of oxygen from the red corpuscles. If there be a hindrance to the circulation, either through valvular defect or through blood-vessels deficient in tone, the same result takes place.

As the greater portion of the heat formed in the body is produced in the muscles, it will easily be seen that the state of the muscular system is of supreme importance. Not merely during exercise, but even in a state of rest, oxidation goes on actively in these organs.

A sound condition of the respiratory system also favours tissue change. If the aerating surface of the lung be small, or if the process of respiration be in any way hindered, whether by external compression or by weakness of the muscles, aeration and consequent oxidation must be small. Disease in the lung interferes with oxidation only in so far as it diminishes the aerating surface or lessens movement.

The skin is one of the most important organs in determining the amount of tissue change. It is the chief apparatus effecting the removal or retention of heat, and thus to a large extent regulates the response to the demand. When the air is cold, and would tend to remove heat to a prejudicial extent, the vessels of the skin contract, the supply of blood to the surface is diminished, and the radiation of heat consequently is lessened. Thus, though the skin itself may be cooled down, the internal organs are preserved from being chilled. When, on the contrary, the external air is hot, when in fact there is little demand

for heat, the vessels of the skin dilate, the surface becomes warm, and radiation is active. Perspiration is increased, and thus the skin removes heat which might otherwise prove hurtful.

Another important factor in determining the individual reaction has still to be pointed out—the influence of habit. The heat-producing apparatus may be set or arranged for a given output. As we have seen, a person in the Tropics exhales less carbonic acid than a person in the Arctic regions; and when the conditions are suddenly changed, the organism requires to adapt itself to its new circumstances. The good and the evil effects alike of a change of climate turn largely on this point. The altered conditions stimulate or relax the energy of various organs. If a demand for increased heat production be made, the result varies according as the demand previously was up to the limit of endurance—of supply—or not. If the organism can easily adapt itself to its new surroundings, and make heat up to the altered requirements, the effect is bracing or tonic. If, on the contrary, the demand is already up to the heat-producing power of the organism, the influence is depressing; the various organs, in proportion to their activity, suffer from impaired nutrition, or nutrition below the present needs of the organism. Now take the opposite case. Suppose the demand for oxidation is lessened, what happens? Here again are two cases. If previously to the change, oxidation was hardly up to the level of requirement, as in the case of a person of low vitality in a cold climate, the effect is tonic or bracing. The oxidation having previously been insufficient to keep up the heat of the body, all the functions are better performed in the less exigent circumstances. If, however, oxidation was easily performed to the full extent of the demand in the cold climate, the diminished removal of heat that occurs in a warm climate causes a sense of oppression, and the climate is spoken of as relaxing.

Change of climate may, therefore, quite apart from its psychical effect, have an enormous influence in altering the

equilibrium of functions, and so, in starting a new and, it may or may not be, better process of nutrition. After a time improvement comes to a standstill, and a return to the original climate may be as beneficial as leaving it in the first instance. Here the altered equilibrium of function seems to be the essential circumstance. The changes of the seasons from this standpoint are not without physiological influence. The reaction of the organism is modified by disease as well as by habit and constitution. Though special climates are suitable for special diseases or special tendencies, this is by no means so much so as is commonly supposed. The suitability of the disease is always subordinate to the suitability of the constitution. In other words, the relation of the oxidising processes to the heat-demands of the climate is of greater importance than the relation of the disease to climate. It must never be forgotten that the processes in question are not fixed and definite things, but, within certain limits, different for different people. From what has been said, it may be inferred that we cannot correctly speak of sedative or stimulant climates absolutely: climate is sedative or stimulant simply in relation to the individual.

This principle is the master key to unlock the difficulties and the details of climatic treatment. In a later section the special modifications induced by various diseases will be dealt with.

In order that tissue change be maintained at a higher rate, more material must be supplied to replace what is consumed. To accomplish this, the digestive and assimilative organs must be in good enough order to respond to a demand for increased activity of function. The determination of this point is not always an easy matter. It often happens that a person who has little appetite and poor digestion begins to eat and to digest well under the stimulus of increased demand, that is to say, the more complete oxidation of the material already supplied. This is especially likely to occur in nervous dyspepsia.

Thus we see that the chief elements in heat production

are (1) a good supply of material to be burnt up or oxidised, furnished by the digestive and assimilating apparatus; (2) a good supply of oxygen to burn it up with; and (3) efficient organs (muscles) to do the burning—that is to say, the muscles must be in sound condition.

Age is an important factor in determining fitness of the constitution for change of climate. Young children do not stand extremes of temperature well. Hot climates are in their case especially pernicious. Children of European parents born in tropical or sub-tropical regions are usually sent home at a very early age. When brought up in the land of their birth, they usually die early or grow up delicate.

Cold climates are less fatal to the young than are hot climates; and if efficient protection is given in the way of warm clothing and good food, children may thrive remarkably well in cold countries.

Old people, like children, suffer readily from extremes of temperature; but, unlike children, they tolerate heat better than cold. Their own heat-producing power being on the decline, cold is a strong depressant, while warmth within reasonable limits is an agreeable stimulant.

Old people also do not, as a rule, accommodate themselves readily to the more active respiration required by a high altitude. Unless the respiratory apparatus has been accustomed to varying degrees of activity, it is apt to lack the elasticity which would enable it to respond without fatigue to the demand for greater play of movement.

Sex is not without influence in regard to climate. Women, while more prostrated by the heat of the Tropics than men, suffer less from those tropical diseases which shorten the lives of so many men. The reason probably is that they are less exposed to morbific influences.

Race powerfully influences the individual response to climate. It is sometimes supposed that man can with impunity fix his home alike in the Arctic regions or in the Tropics. As a matter of fact, a man becomes acclimatised readily only in countries having very nearly the same mean

temperature as the country to which his race belongs. Individuals may live in seeming health in climates much hotter or colder than their own. But their posterity does not fare equally well: their descendants melt away, and hardly a survivor remains to the third or fourth generation. The attempt to colonise directly a land having a mean temperature widely different from that of the native land of the colonists has always ended in failure.

The Romans established their dominion in the north of Africa, and, by magnificent buildings, roads, and improvements in the country, sought to make their occupation permanent. Not a trace of their existence remains to-day, except the ruins of the structures they had erected. Their numbers could be kept up only by continuous reinforcements, and the lapse of a few generations in fact sufficed to wipe them out of existence.

The Vandals at a later period occupied the same country. They were the most robust and most adventurous of the Teutonic tribes that overran the south of Europe. Pressing beyond their comrades in arms, they reached a land that seemed in their eyes even more favoured than other parts of "the sunny South." Scarcely more than a century elapsed before these hardy warriors had dwindled in number and in strength, and fell an easy prey to the troops of the Eastern Empire under Belisarius.

Italy, France, Spain, had all been conquered and occupied by Teutonic tribes; but the nations that dwell in these countries to-day are still essentially of Latin origin.

Thus the nations of northern and mid-Europe did not thrive in the South; those of southern Europe were unable to perpetuate their race in north Africa. The tribes of the far North find even the climate of Sweden relaxing, and do not flourish there.

A more striking example is afforded by the history of the various occupations of Egypt by northern nations. The Mameluks, typical warriors of the most robust type, conquered the country and held it for centuries; yet they were unable even during this prolonged period to raise up

a vigorous progeny of their own. Their children were weakly, and a third generation was seldom reached. They would have disappeared from the land but for the constant renewal of their numbers by Circassian slaves. The inhabitants of Egypt, though many times conquered, and though their land had been overrun and occupied by the various nations of Europe, are to-day almost identically the same race as in the days of the Pharaohs.

As a general rule a race can be directly and at once acclimatised only in countries having a mean temperature not far removed from that of its native land; though by gradual movements through successive generations perfect acclimatisation may be attained even in countries widely differing in temperature from the original home of the race. This acclimatisation is greatly aided by intermarriage with the natives of the country occupied.

Acclimatisation takes place much more readily towards the Polar region than towards the Equator. The French race have multiplied and prospered in Canada, while in the tropical and sub-tropical portions of America, in the West Indian Islands, they have at the utmost held their own, and in most cases have kept up their numbers either by intermarrying with the natives or by renewed immigration from the mother country. While in the Antilles and other West Indian Islands the French have maintained their numbers only at an enormous sacrifice of life, the Spanish and Portuguese have without difficulty become perfectly acclimatised and thoroughly naturalised to the soil. The Anglo-Saxon race has in this respect not been more fortunate than the French. The only really thriving European settlements in the warmer portions of South America are of Spanish and Portuguese origin. The expression "thriving" here has reference not to political or commercial prosperity but merely to growth in number or increase of population by development from within.

Certain races have shown extraordinary facility in accommodating themselves to climates of the most dissimilar character. The Jewish and the Gipsy races are

especially distinguished in this respect. The Jew presents the nearest approach to a cosmopolitan type. Originally from Syro-Arabia he can readily stand the hotter portions of the globe. In southern Europe, as well as in the tropical and sub-tropical regions of America, Jews are found in great numbers pursuing the same life of mental activity and of bodily temperance that characterises them elsewhere. From the South to the colder regions of the North Jews are found in gradually decreasing numbers.

In a less pronounced degree have the people of the South suffered on first travelling north. It is true that Nubians coming up from the equatorial regions perish in Egypt like flies; but in this case climate is only one factor in the result, bad hygienic arrangements being mainly responsible for inducing great liability to disease, rapid spread of infectious ailments, and a frightful mortality.

A seeming exception or modification of the general law —that acclimatisation takes place readily only in countries with nearly the same mean temperature—has still to be mentioned. The newcomer from a temperate climate for a time tolerates the extreme cold of the Arctic regions and the extreme heat of the Tropics better than do the inhabitants or natives themselves. Almost every nation in Europe was represented in the disastrous campaign in Russia in 1814. The cold of that winter was the most intense within the memory of the inhabitants. Invader and native alike suffered; but the different nationalities suffered in different degrees. Contrary to what might have been expected, the natives suffered most; then the nations of mid-Europe, while the men of the warm lands of the South escaped with but little injury.

Again, it is a subject of common remark that Creoles who visit Paris for the first time feel the cold of winter surprisingly little, less even than the ordinary people of the place, going about much less wrapped up than the inhabitants of the country. After residing for some time in the country, they become sensitive to the cold, and in a year or two they are anxious to get back to their own

land. A kindred phenomenon is observed when a European goes to a tropical or sub-tropical climate. At first the heat is well borne, and the newcomer goes about with life and activity as he would at home. Speedily his excessive energy subsides, and he is apt to fall into a state of listlessness.

Can any explanation be given of this seeming anomaly? The explanation is probably to be found in a fundamental law of animal and vegetable life—a law of periodicity, of recurrence, of ebb and flow of function, of alternation of rest and activity, of nutrition and of discharge. When the heat-producing functions have been working up to their highest pitch of activity, a falling off in the demand is welcomed as a physiological rest by the organs concerned. In like manner, after a period of low activity, an increase in the demand permits the discharge of stored up or accumulated energy. But when the new condition is kept up longer than such changes usually are, the overpowering influence of physiological habit asserts itself. In a low temperature a diminishing response is made to the continuous stimulus of intense cold; in a constantly high temperature the heat demands become less than sufficient to carry off the products of combustion.

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# PART III

## CLIMATES AND HEALTH RESORTS

# CHAPTER XIII

## TYPES OF CLIMATE

Hitherto our work has been chiefly analytical. Up to the present we have concerned ourselves with analysing, on the one hand, the factors of climate, and, on the other hand, the physiological influence of those factors. Now our task is to take the factors of climate as we find them combined in nature, and to consider the physiological action resulting from their union.

The classification of climates has been a source of the utmost difficulty to the medical climatologist. In the arrangement of climates according to geographical position, two principles of division have been chosen—distance from the Equator, and distance from the sea.

When the Equator is taken as the starting-point of classification, climates are divided into :—

1. Tropical.
2. Sub-tropical.
3. Temperate.
4. Cold.
5. Arctic.

When proximity to the sea is taken as the *fundamentum divisionis*, we have :—

1. Sea climates : subdivisions ranging from Tropical to Arctic.
2. Submarine, or borders of the sea.
3. Inland climates : (*a*) lowland ; (*b*) medium altitude ; (*c*) high altitude.

The meteorological factors of climate have almost all been used as principles of classification. The amount of humidity, the temperature, and the pressure of the air have, each in turn, served this purpose. In regard to humidity, climates have been divided into moist, medium, and dry; and subdivided according to temperature; and when temperature has been chosen as the principle of division, climates in like manner have been divided into hot, temperate, and cold; and subdivided according to their humidity or dryness. Each of these classifications may have a use of its own for the meteorologist or for the geographer. To the physician, however, they are not merely valueless, but misleading. To the physician a classification is of use only in so far as it groups together climates having a somewhat similar physiological action. One would naturally suppose that, in the classifications just described, a common physiological principle underlies the division into groups. So far is this from being the case, that every writer on medical climatology specially warns his readers to the contrary; and one writer, perhaps the most eminent living authority on the subject, says, "The deficiencies connected with every kind of classification appear to us so great that we might almost feel disposed to proceed alphabetically."

Certain other writers have divided climates, according to a physiological basis, into tonic or stimulant, and sedative or relaxing. In this classification the needs of the physician are consulted; and to a certain extent the classification is of value, but it is open to a fatal objection: it is based on a shifting principle of division. It overlooks the simple yet fundamental fact that the action of climate is relative to the individual; that the action of climate is conditioned by the reaction of the organism; that a climate that is relaxing to one person is tonic to another. This is merely an example of the principle underlying the old proverb that what is one man's meat is another man's poison.

The physiological classification just mentioned has a certain merit. Its aim is right. It keeps in view the

purpose for which medical climatology exists. It fails in its purpose because the principle of division is not sound; because an accidental circumstance is taken instead of the essential one.

The classification now to be proposed proceeds also on a physiological basis. It takes as foundation the circumstances by which a climate is tonic or relaxing; by which, in fact, the same climate may be tonic to one person and relaxing to another. We shall find as we investigate the matter that this principle of division considers not merely a single meteorological feature, but all the chief elements that go to make up a climate.

The principle of division that I propose is *the demand made by the climate for the production of heat.* This corresponds with the demand for tissue change. Now the tonic or relaxing character of a climate turns chiefly on the ability of the organism to adapt itself to the requirements. Other things being equal, that climate is most tonic which demands the greatest amount of tissue change that a given organism can permanently yield. Subdivisions are made according as the heat demand is regular or irregular.

How is this principle of division to be applied? Have we as yet the means of arranging climates in accordance with such a principle? Previous meteorological and geographical classifications have roughly and dimly recognised this principle. When climates have been divided into warm and cold, into moist and dry, there can be little doubt that the idea at bottom was the principle here put forward. But through elevating one meteorological factor out of its due rank such classifications were predestined to failure. The humidity of the air and its motion or stillness, equally with temperature, are essential factors in determining the rate at which heat is removed. In some instances they all act together in the same direction. In other instances they pull in opposite ways, one compensating or balancing the influence of another.

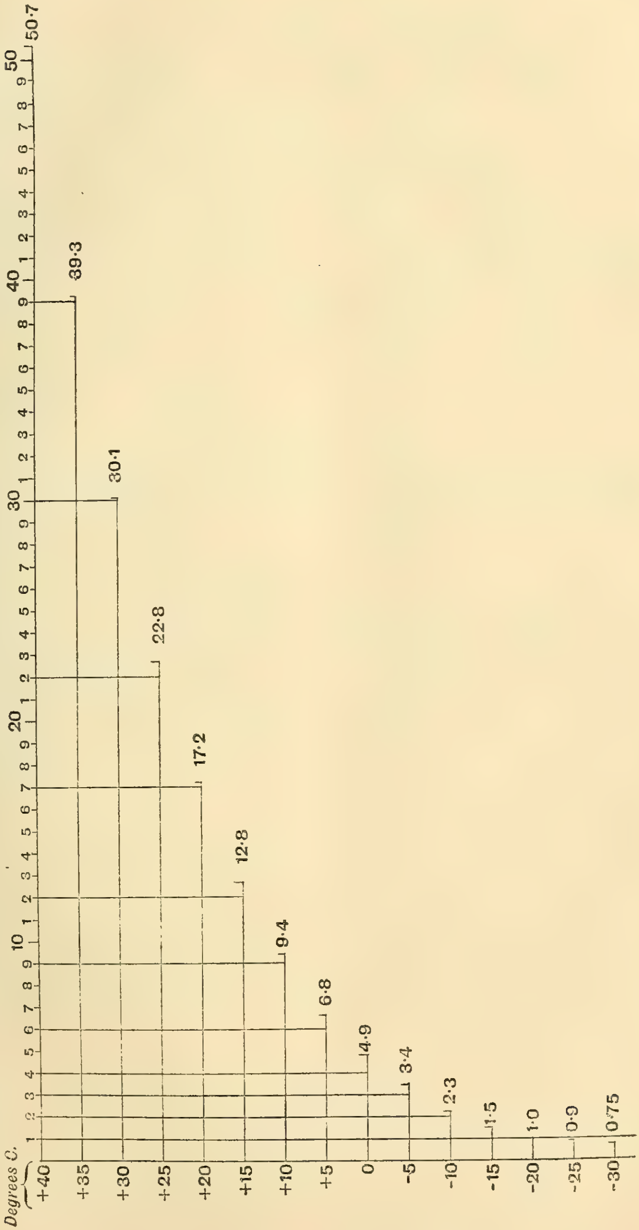
In the proposed classification it will be seen that climates are arranged in series. At the head of the list stand those

that make little demand for heat production; at the bottom of the list stand those that make the greatest demand. It must not, however, be supposed that the gradation is regular throughout. As shown in the classification, differences are observed not merely in passing from one member of the series to another; certain members of the series are themselves characterised by rapid variations in their requirements.

Temperature, it will be seen, is the only meteorological factor that retains its place as an element of classification for all climates. At one end of the scale the presence or absence of moisture is the most important feature in determining the heat requirements. At the other end of the scale its influence is replaced by the presence or absence of wind.

This point is of such great importance that a little time may be well bestowed in fully understanding it. The accompanying diagram shows the amount of moisture that can be held in the form of vapour in the air at different temperatures. In an earlier section of this work the subject was dealt with; but the interest and importance attaching to it warrant a certain amount of repetition. To illustrate the use of the accompanying diagram, let us take an example. Suppose the temperature of the air is 30° C. (86° F.) and its relative humidity 80 per cent, it is still further from saturation than absolutely dry air at freezing-point. Thus at 30° C. a cubic metre of air is capable of holding 30·1 grammes of water in the form of vapour; and when it contains only 24 grammes, or 80 per cent of moisture, it is still capable of taking up 6 grammes, whilst absolutely dry air at freezing-point can take up only 4·9 grammes of water. Air at 25° C. is saturated with 22·8 grammes of water-vapour. Therefore if air at 30° C. and 80 per cent relative humidity falls in temperature to 25° C., not merely does the air become saturated with moisture, but there is an actual precipitation of 1·2 grammes of water per cubic metre of air. In the case of air at 0° C. and 80 per cent relative humidity, a fall of 5° C. in

GRAMMES OF WATER-VAPOUR PER CUBIC METRE REQUIRED TO SATURATE AIR AT VARIOUS TEMPERATURES

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temperature would cause a precipitation of only 0·5 grammes of water per cubic metre of air.

To illustrate the joint action of heat and moisture let me quote from travellers in hot, damp climates. Humboldt[1] says: "We had not yet been two months in the hot Zone, and already our organs were so sensitive to the slightest change of temperature that, through shivering with cold, we were unable to sleep; and to our astonishment we saw that our thermometer registered 21·8° C. (71·24° F.). In the year 1803, when we were at Guayaquil, the natives of the place complained of cold, and wrapped themselves up when the thermometer fell to 23·8° C. (74·84° F.), whilst at 30·5° C. (86·9° F.) they found the heat oppressive. A change of not more than 7 or 8 degrees sufficed to bring about the opposite sensations of shivering and of oppressive heat. On the coasts of the South Sea the ordinary temperature of the air is about 28° C. (82·4° F.). In Cumana during a heavy rainfall one hears people calling out in the streets, 'How icy cold it is! I am frozen!' And yet a thermometer exposed to the rain falls only to 21·5° C. (70·7° F.). From all these observations it appears that in low-lying tropical countries, where the temperature by day is almost constantly over 27° C. (80·6° F.), one finds it necessary to cover oneself up at night whenever in this moist air the thermometer falls 4 or 5 degrees."

Dr. Borius,[2] in his description of the climate of Senegambia, says that "whilst in France after a hot day—the temperature rises as high as on the coast of Senegambia, or even higher—one sits out of doors in the evening without risk, and with a feeling of pleasure: on the Senegal after sundown one cannot safely expose oneself to the open air, and the slightest cooling gives rise to a sensation of great cold."

## CLASSIFICATION OF CLIMATES

### Group I

CLIMATES WHERE THE HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) IS EXCESSIVELY SMALL

| *Meteorological Characters*— | *Physiological Characters*— |
|---|---|
| Hot climates: temperature over 71·6° F. (22° C.). | Demand for heat and for tissue change so small that there is difficulty in getting rid of the heat formed by the healthy body when production is at its lowest. |

*a.* Heat Demand (*or* Demand for Tissue Change) Regular.

| | |
|---|---|
| Dry: mean relative humidity under 60 per cent. | Fluctuations in heat demand fairly regular and comparatively small. |

*b.* Heat Demand (*or* Demand for Tissue Change) Irregular.

| | |
|---|---|
| Not-dry: mean relative humidity over 60 per cent. | Fluctuations in heat demand irregular and comparatively great. |

Wind largely increases the heat demands made by atmospheric humidity, but does not greatly increase the heat-removing power of dry hot air.

### Group II

CLIMATES WHERE THE HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) IS SMALL

| *Meteorological Characters*— | *Physiological Characters*— |
|---|---|
| Warm climates: temperature 60·8 to 71·6° F. (16 to 22° C.). | Demand for heat small, but such that heat normally produced can be easily removed. |

*a.* Heat Demand (*or* Demand for Tissue Change) Regular.

| | |
|---|---|
| Dry: mean relative humidity under or about 66 per cent (from 72 per cent at 16° C. to 60 per cent at 22° C.). | Fluctuations in heat demand regular and controllable by clothes and shelter. |

*b.* Heat Demand (*or* Demand for Tissue Change) Irregular.

| | |
|---|---|
| Not-dry : mean relative humidity over 66 per cent. | Fluctuations in heat demand irregular and not easily controlled. |

Wind intensifies the heat-removing action of atmospheric moisture, but increases only slightly the heat-removing action of dry warm air.

## Group III

### CLIMATES WHERE THE HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) IS MEDIUM

| *Meteorological Characters*— | *Physiological Characters*— |
|---|---|
| Temperate climates: temperature 48·2 to 60·8° F. (9 to 16° C.). | Medium or normal heat demand for white races. |

*a.* Heat Demand (*or* Demand for Tissue Change) Regular.

| | |
|---|---|
| Dry: mean relative humidity under or about 75 per cent (from 78 per cent at 9° C. to 72 per cent at 16° C.). | Fluctuations in heat demand moderate in amount and regular, except in so far as they depend on wind, and then controllable. |

*b.* Heat Demand (*or* Demand for Tissue Change) Irregular.

| | |
|---|---|
| Not-dry: mean relative humidity over 75 per cent. | Fluctuations in heat demand irregular and relatively large in amount. Fluctuations due to wind not easily controlled. |

Wind intensifies the action of moisture in removing heat, especially at the lower temperatures.

## Group IV

### CLIMATES WHERE THE HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) IS LARGE.

| *Meteorological Characters*— | *Physiological Characters*— |
|---|---|
| Cool climates : temperature 33·8 to 48·2° F. (1 to 9° C.). | Large demand for production of heat. |

*a.* Heat Demand (*or* Demand for Tissue Change) Regular.

| | |
|---|---|
| Dry: mean relative humidity under or about 79 per cent (from 80 per cent at 1° C. to 78 per cent at 9° C.). | Fluctuations in heat demand regular, and moderate in amount, except in so far as they depend on wind, and then controllable. |

*b.* Heat Demand (*or* Demand for Tissue Change) Irregular.

| | |
|---|---|
| Not-dry: mean relative humidity over 79 per cent. | Fluctuations in heat demand irregular, relatively large in amount, and not easily controllable. |

Wind greatly intensifies the action of low temperature and of atmospheric moisture in carrying off heat. Clothing gives efficient protection against dry, but not against moist cold air

## Group V

### CLIMATES WHERE THE HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) IS EXCESSIVE

| *Meteorological Characters*— | *Physiological Characters*— |
|---|---|
| Cold climates: temperature under 33·8° F. (1° C.). | Very large demand for production of heat. |
| The mean relative humidity at the temperatures included in the present group is usually high, about 80 per cent or more; but the absolute humidity is so small that the relative humidity has little physiological significance except indirectly through its action on cloud. | Fluctuations in heat demand considerable, generally fairly regular, and for the most part under control, except in so far as they depend on wind. |

Wind enormously increases the heat-abstracting power of a low temperature.

## EXAMPLES OF THE VARIOUS TYPES OF CLIMATE.

### Group I.

HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) EXCESSIVELY SMALL.

Hot climates: temperature over 71·6° F. (22° C.)

*a.* Heat demand regular.
Dry: mean relative humidity under 60 per cent.

*b.* Heat demand irregular.
Not-dry: mean relative humidity over 60 per cent.

The north-west and northern portion of India is for the most part extremely dry as well as hot during the summer months. In Bickanir the mean temperature in the shade from March to October lies between 77 and 95° F.; and the mean relative humidity for the same months lies between 32 and 61. In Jacobabad the mean temperature for these months ranges from 74 to 96° F., and the relative humidity between 36 and 58. Colonel Giles[3] says: "The man who 'sent back for his blankets' resided, I believe, during life somewhere in the United States; but I fear he must have been a person of comparatively small endurance, as in the entire American continent there is no spot that in the matter of heat is in the same field with Jacobabad, where 127° F. (52·8° C.) in the shade has actually been registered, and, in fact, the whole of Scind easily 'licks creation' in this unenviable detail."

Bombay affords an example of a moist hot climate. The mean temperature from January to December ranges from 76 to 88° F., and the relative humidity from 69 to 87. Madras has much the same type of climate, but is less moist. Calcutta from March to November is hot and moist, but in December, January, and February the mean temperature is from 65 to 70° F., the relative humidity for the same time ranging from 69 to 72.

Cairo may be taken as an example of the different climates represented by the different seasons.[4]

| | |
|---|---|
| Example of dry hot climate . | Cairo, May to August. |
| „ moist „ „ . | „ September and October. |
| „ dry warm „ . | „ March and November. |
| „ „ temperate climate | „ December, January, and February. |

[Table

| Cairo. | Temperature. | | Relative humidity. |
|---|---|---|---|
| | | ° F. | Per cent. |
| Dry hot climate . . | May . | 75·2 | 48·4 |
| " . . | June . | 82·6 | 44 |
| " . . | July . | 83·8 | 49 |
| " . . | August . | 82·2 | 55·3 |
| Moist hot climate . . | September | 77·8 | 62·1 |
| " . . | October . | 74·3 | 65·8 |
| Dry warm climate . . | March . | 62·8 | 56·2 |
| " . . | April . | 70·4 | 47·8 |
| " . . | November . | 64·4 | 67·5 |
| Dry temperate climate . | December . | 58·4 | 69·6 |
| " . | January . | 53·6 | 69·7 |
| " . | February . | 57·0 | 66·2 |

## Group II

### HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) SMALL

Warm climates: Temperature: 60·8 to 71·6° F. (16 to 22° C.)

*a.* Heat demand regular.

Dry: mean relative humidity under or about 66 per cent (from 72 per cent at 16° C. to 60 per cent at 22° C.).

*b.* Heat demand irregular.

Not-dry: mean relative humidity over 66 per cent.

Nearly every type of climate is represented in India.

From May to September Simla at an elevation of 7048 feet is warm, the mean temperature ranging from 61 to 67° F. The mean relative humidity of May is 49; of June, 64; that is, distinctly dry. In July, August, and September the mean relative humidity is from 82 to 91; that is, distinctly moist. March, April, October, and November, with mean temperatures between 49 and 58° F., are temperate and at the same time dry, the relative humidity of these months ranging from 50 to 53. In December, January, and February the weather is cold and dry, the mean temperature ranging from 41 to 45° F., and the relative humidity from 47 to 58.

Las Palmas in Grand Canary has a mean temperature ranging from 62·3 to 71·4° F. for the nine months from October to June. The mean relative humidity for these months is from 67 to 70—that is, a moderate degree of humidity for the temperature. July, August, and September can just be included in the type of hot climates. The

relative humidity during these warmer months ranges from 65 to 70 per cent ; which also may be regarded as a medium degree of humidity for the temperature.

Orotava stands on the borderland between temperate and warm climates in the winter months, and between the warm and hot climates in July, August, and September. The mean humidity for the year ranges between 73 and 80—that is, rather moist for the temperature. Funchal in winter also is close to the borderland between temperate and warm climates, while in summer it just touches the class of warm climates. The humidity is about medium for the temperature.

## Group III

### HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) MEDIUM

Temperate climates : Temperature : 48·2 to 60·8° F. (9 to 16° C.)

*a.* Heat demand regular.

Dry : mean relative humidity under or about 75 per cent (from 78 per cent at 9° C. to 72 per cent at 16° C.)

*b.* Heat demand irregular.

Not-dry : mean relative humidity over 75 per cent.

Of temperate climates Ootacamund in India at an elevation of 7252 feet may be taken as perhaps the most perfect example. The mean temperature throughout the year lies between 48 and 59° F. The mean relative humidity varies between 46 per cent and 71 per cent between December and May, and between 79 per cent and 90 per cent from June to November. Blanford,[5] speaking chiefly of Ootacamund, the summer residence of the Madras Government, says : "One could hardly desire, and it would certainly be hard to find within the limits of the Indian empire, or perhaps elsewhere, a more charming climate, or one more fitted to the European constitution, than that of the Nilgiri hills. The Laureate has sung of the 'sweet, half-English Nilgiri air'; but it is the air of the English spring and summer, without Atlantic storms or the bitter east winds of March ; a climate where one may inhale the fresh breeze that blows over rolling downs, and brave with impunity the ardour of a tropical sun, and even enjoy the cheerful companionship of an evening fire through the greater part of the year. The flowers of Southern Europe and well-flavoured English vegetables flourish with a luxuriance unknown in the Torrid Zone, save on such as this and its sister hill groups, the Shevaroy and Pulni hills. Shielded by the Kùndah and Makùrti ranges from the heavy rainfall of the Western Ghats, fine and cool cloudy weather is the rule rather than the exception, even in the summer monsoon ; and

in mid-winter the clear frosty atmosphere of the early morning is warmed up daily by a genial unclouded sun, and day follows day untroubled by snowstorms and free from their unwelcome sequelæ—thaws, slush, and catarrh. Without the grandeur of the Himalayan gorges, or the majesty of eternal snow, the Nilgiris have a soft beauty of their own, recalling to the Englishman the undulating contours of his own western hills ; and the pedestrian can strike a bee-line over hill and dale, whithersoever his fancy leads him, unimpeded by any obstacle more serious than an occasional peat-bog or a brawling hill-stream. Among all the pleasant memories of more than thirty years of Indian life, and an experience of all parts of the empire from Peshawar to Sibsagar and Point de Galle, I can recall no more charming scene and climate than those of the Nilgiri hills. Many an old Anglo-Indian whom choice or necessity has led to fix his home in India, has found in these hills scenery as beautiful and a climate as enjoyable as any in the most favoured lands of the Mediterranean shores."

The spring and summer throughout the United Kingdom represent the not-dry temperate group of climates ; though a few places tend in July and August to pass into the class of warm climates.

The Riviera from November to April has a dry temperate climate, though at Cannes, Nice, and San Remo, December or January is cool rather than temperate.

Egypt from Cairo to Assouan has a dry temperate climate during December, January, and February ; March, April, and November are warm ; the other months hot.

Algiers is temperate and of medium humidity in December, January, February, and March ; warm in April and November.

The climate of Melbourne is dry and temperate from April to October ; dry and warm from November to March. Melbourne is rather windy, the velocity of the wind for the greater part of the year being from ten to over eleven miles an hour ; in April, however, it is a little under nine and in May a little over nine miles an hour. The significance of the wind is due, not to the temperature, but to the dust.

Cape Town is temperate from May to October ; warm from November to March. The relative humidity is always fairly high. In Aliwal North the climate is dry and temperate from April to September ; dry and warm from October to March. The same description applies pretty closely to most of the high ground of South Africa ; though in some places, as, for example, in Bloemfontein, the climate in December and January is hot. Owing to the dust, wind is a great plague.

Davos, during the summer months—June till the middle of September—has a temperate climate of medium dryness, which stands in marked contrast to its cold winter climate.

### Group IV

HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) LARGE

Cool climates: Temperature: 33·8 to 48·2° F. (1 to 9° C.)

*a.* Heat demand regular.

Dry: mean relative humidity under or about 79 per cent (from 80 per cent at 1° C. to 78 per cent at 9° C.).

*b.* Heat demand irregular.

Not-dry: mean relative humidity over 79 per cent.

The winter climate of the United Kingdom from November to April represents the not-dry type of cool climates. The climate of Montreux from November to March is very similar.

The winter months, from November to March, at Meran afford the type of a dry cool climate. The months of April and May and again of September and October at Davos and St. Moritz belong to the same class.

### Group V

HEAT DEMAND (*OR* DEMAND FOR TISSUE CHANGE) EXCESSIVELY LARGE

Cold climates: Temperature under 33·8° F. (1° C.)

Mean relative humidity usually over 80 per cent, but not of importance, the absolute humidity being so small as to be devoid of physiological influence except indirectly by the formation of cloud, which diminishes the loss of heat by radiation.

In cold climates wind has to some extent the action that belongs in hot climates to moisture as a heat-removing agent.

Davos and the other Alpine resorts from November to March represent the cold climates. In Davos the mean temperature during these months ranges from 18·6° F. (– 7·4° C.) in January to 29·3° F. (– 1·5° C.) in November. The mean relative humidity is from 79 to 84; but the absolute humidity ranges from 2·29 millimetres—the elastic force of vapour—in January to 3·44 mm. in November.

The high-lying resorts of the Rocky Mountains also have a cold climate during December, January, and February. During these three months the mean temperature of Denver ranges from 27·2° F. in January to 32·1° F. in February. In Colorado Springs the mean temperature is 24·0° F. in December, 26° F. in January, and 26° F. in February. The mean relative humidity for Denver during these three months ranges from 53 to 55 per cent. These figures are remarkably low in com-

parison with the corresponding figures for Davos; but it is an interesting fact that the absolute humidity is almost the same for Denver and for Davos, which lie both at about the same altitude. Owing to the lower relative humidity and consequently smaller amount of cloud, Denver has a greater proportion of possible sunshine than has Davos. The following table from Dr. Solly's *Medical Climatology*, p. 253, shows this:—

| Sunshine Records. | Monthly Means. | | | | |
|---|---|---|---|---|---|
| | Winter. | Spring. | Summer. | Autumn. | Year. |
| Percentage of possible sunshine— | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| Denver . . | 62 | 60 | 66 | 71 | 65 |
| Davos Platz . | 57 | 52 | 55 | 52 | 54 |
| Hours of actual sunshine— | Hours. | Hours. | Hours. | Hours. | Hours. |
| Denver . . | 188 | 242 | 290 | 243 | 240 |
| Davos Platz . | 100 | 166 | 196 | 126 | 147 |

The influence of solar radiation on the body has been estimated by Rubner and Cramer.[6] These authors arrived at the conclusion that the sun temperature, as shown by a vacuum thermometer with the centigrade scale, if halved and added to the shade temperature expresses the combined effect of sun and of shade. Thus if the temperature in the shade is 10° C. and the black-bulb thermometer *in vacuo* shows the solar radiation to be 30°, the combined effect is 25° C. thus:

$$10 + \frac{30}{2} = 25.$$

In making this calculation with the Fahrenheit scale we must deduct 32 from the sun temperature before halving it.

Owing to the greater force of solar radiation in the mountains, the shade temperature is not quite comparable with the shade temperature in the lowlands. When this element is taken into consideration, Colorado Springs and Denver might be regarded as belonging in winter to the cool rather than to the cold climates. However, the cooling influence of the high winds prevalent at these resorts—9 miles an hour at Colorado Springs and over 6 miles an hour at Denver—tends to outweigh the warming influence of the high solar radiation.

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# CHAPTER XIV

## HEALTH RESORTS

### Prefatory Remark

In the following brief account of the more important health resorts, each geographical area is treated more or less as an independent whole. That is to say, places are not removed from their geographical setting in order to class them under their physiological heading. The indications given under "Types of Climate" will serve as a guide to refer any climate to its proper group.

### Egypt

Under the name of Egypt a large tract of country is included, embracing the valley of the Nile, and a considerable portion of the desert. But the only part of this region that interests the medical man is the narrow strip of inhabited territory that borders the Nile for about six or seven hundred miles from its mouth. To the river alone is due the fertility of this piece of country and the possibility of living in it. Beyond the reach of the inundations or irrigations from the river the land is a barren and sandy wilderness, some two or three spots or oases excepted.

The places in Egypt which chiefly interest the physician are Alexandria and its neighbour Ramleh, Cairo, Helouan, Mena House, Luxor, and Assouan.

Alexandria is a seaport town, with a population of nearly 500,000 inhabitants. It is quite unsuited as a residence for invalids, its climate being damp and windy; and owing to these circumstances alternations of heat and

cold are extremely trying. Ramleh, almost a suburb of Alexandria, is a pleasant seaside resort in summer.

Cairo, about 130 miles from the coast, is the seat of the Egyptian Government, and has nearly 600,000 inhabitants. The city itself is not a place for invalids, or at any rate for invalids with lung disease. Two or three excellent resorts, however, are in its immediate neighbourhood. Helouan, for example, is about 14 miles away, and Mena House 8 miles, close to the pyramids of Gizeh. About 450 miles south of Cairo is Luxor, a small village occupying part of the site of ancient Thebes. Assouan is 130 miles farther still. All these places have a climate very much in common, the differences in temperature and in relative humidity being what might be expected, according as the place is farther south as Luxor or Assouan, or farther away from the river as Gizeh.

The winter climate of Cairo is dry and temperate. The winter climate of Luxor borders on the dry and warm group; and the winter climate of Assouan is well within the dry and warm group. The heat demands, or the demand for tissue change, is accordingly medium or small with regular variations.

Until recently the climate of Cairo was more fully known than that of any other Egyptian station. The admirable observations of Dr. Leigh Canney,[3] Dr. Page May,[4] and others, now furnish trustworthy information concerning Assouan, Helouan, Luxor, and Mena House.

The winter climate of Egypt is marked by great regularity, as compared with European climates. There are fewer of those violent changes from the weather of one day to the weather of the next than are to be found in perhaps any other countries resorted to by invalids. Nevertheless the daily oscillation of temperature is considerable, amounting commonly to from 17 to 25 or even 36 degrees Fahrenheit. Occasionally the daily range of temperature is as low as 8° F., and occasionally it exceeds 40° F.

Owing to the greater dryness of the air these oscillations of temperature are more marked at Assouan and at Luxor

than at Cairo, at Helouan, or at Mena House. In all the Egyptian stations the mornings and evenings are cool—it may be even cold—while the day from eleven to three or four o'clock is distinctly warm. This alternation of temperature is one of the charms of Egypt, making the heat bearable, and giving a sense of buoyancy and elasticity to the inhabitants.

These changes of temperature, pleasant though they are, are sometimes blamed as apt to cause chills; and indeed owing to imprudence they may do so, but a very small amount of common-sense in regard to clothing, exercise, and so on, suffices to avert risk.

Luxor may be taken as being roughly 4 degrees Fahrenheit warmer than Cairo, Mena House, or Helouan; and Assouan as 5° F. warmer than Luxor. The mean daily range of temperature in the months from December to March for two years was the same at Luxor and at Assouan, namely, 28·5° F., while at Helouan it was 22·3° F.,—that is, 6° F. less. The relative humidity is 15 or 20 per cent lower at Assouan than at Mena House or at Helouan. The mean velocity of the wind at Helouan in the winter months is rather more than two miles an hour, and is stronger during the daytime than at night by nearly 70 per cent. Assouan has more wind than Helouan, but is less dusty than Luxor, and probably also than Helouan or Mena House.

The number of days in the year on which rain occurs at Cairo varies from about nine to seventeen, nearly all in the spring and winter months; and the rainfall is only little more than an inch. At Alexandria rain is two or three times as frequent, and six or seven times as much in amount. Rain occurs less frequently at Mena House and at Helouan than at Cairo, and rarely at Luxor and Assouan.

The average relative humidity in the hours from 10 A.M. till 6 P.M. for the four months from December to March was at

| Mena House. | Helouan. | Luxor. | Assouan. |
|---|---|---|---|
| 51·7 | 42·7 | 36·3 | 30·5 |

The average amount of cloud at Cairo is less than four-tenths for the winter months. In Luxor and Assouan it is still less.

The prevalent ailments of the country, ophthalmia and dysentery, can be avoided by proper precautions.[1]

The general principles for the selection of cases will be found in a later section.

The slighter afebrile cases of tuberculosis in patients of weakly constitution or in patients who cannot support a cold climate are suitable for Egypt. Owing to dust and to the excessive dryness of the air, irritable conditions of the larynx are unsuitable. Hæmoptysis or a tendency to bleeding from the lungs is not regarded by the local practitioners as a contra-indication. Asthmatic and emphysematous patients are not infrequently much relieved during their stay in the country. Bronchitis, with abundant secretion, usually does well; but patients of this class, and indeed all who are subject to catarrhs of the upper air-passages have to be on their guard in the cool evenings after the hot days. The cold north winds on the Nile in January are trying to many invalids, but are felt less on the up-trip.

Rheumatic patients commonly do well in Egypt. Acute rheumatism, Dr. Sandwith[2] tells us, is extremely rare. Rheumatoid arthritis, chronic muscular rheumatism, chronic gouty conditions, are all reported to be very favourably influenced by the climate. Helouan by virtue of its baths, and Assouan by virtue of its extra dryness and greater warmth, offer special advantages to patients suffering from these ailments.

For Bright's disease the winter climate of Egypt, especially of Assouan, is as favourable as any that can be found.

Persons suffering from chronic degenerative affections of the nervous system may often with advantage spend the winter in Egypt. The early stages of locomotor ataxy or of cerebro-spinal sclerosis, according to Dr. Leigh Canney,[3] do well.

In no place is it more advisable than in Egypt for the

invalid to take medical advice on arrival. By so doing he can make the best use of his time, and perhaps avoid serious illness.

The season in Egypt is roughly from the middle or end of November till April. Towards the end of March Assouan and Luxor are forsaken for the more northern stations. The Khamseen or wind from the desert is cold in the winter months, but from March on becomes hot and oppressive. European residents do not, as a rule, find the heat of Cairo unpleasant in May, and do not generally leave the country for cooler regions till the end of May or beginning of June. The Nile reaches its lowest level in May, and the relative humidity of the air is at its lowest then and in June. From August till October the air is comparatively damp, owing to the Nile floods and the water impounded in irrigation basins.

Ramleh, close to Alexandria, affords a pleasant seaside change in the hot weather.

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# CHAPTER XV

## SOUTH AFRICA

WITHIN recent years South Africa has acquired considerable reputation as a health resort for consumptives. But South Africa is a large country, and embraces within its limits a variety of climates. Not all of these are suitable for invalids. The parts sought are chiefly the elevated inland plateaux, the coast-line being as a rule avoided.

The surface form of the country is peculiar, and is marked by simplicity and regularity. From the coast inland the ground rises in great steps of stairs, as it were, each step separated from the next by an intervening ridge of mountain. The first step or coast plateau is from about 300 to 600 feet, or even 1000 feet above the level of the sea. Towards the west the second step is known as the Southern Karroo. Its average height is about 1200 feet. Next comes the Central or Great Karroo, lying between 2000 and 3000 feet above sea-level. Beyond this is the Northern Karroo, ranging from 2800 to 6000 feet above the sea. It stretches as far north as the Orange River; and, indeed, the softly undulating country of the Orange River Colony and of the Transvaal must be regarded as a continuation of it. In the eastern uplands of Cape Colony, in Natal, and in the adjoining country the stairs configuration is hardly so well marked, the steps having been partly obliterated, and in some places the coast plateau has been worn away by the sea.

The great plains known as Karroos yield evidence of having once been covered by vast lakes. Fossil skeletons of

extinct amphibians have been found in considerable numbers. The only lake of the same type still remaining is said to be Lake Ngami, and its waters are fast shrinking. The term karroo is an old Hottentot word signifying dry or barren. Desert-like though it is in ordinary circumstances, the soil is extremely fertile, and when watered, whether by river, artesian well, reservoir, or thunderstorm, becomes speedily clothed with vegetation in great luxuriance.

One of the first things to strike the European on visiting South Africa is that the sun appears to be going the wrong way. In moving across the heavens he passes from right hand to left. At night the sky is dotted with unfamiliar stars. The reality of being in the Southern hemisphere soon takes possession of the mind. The seasons are the opposite of our own. July is in midwinter; Christmas is in midsummer. Then we learn that in South Africa there are really only two seasons — a long summer lasting from October to March, and a long winter lasting from April to September. A more curious piece of information about the seasons still awaits us. Winter—April to September—is the rainy season along the south-west coast, and summer—October to March—is the dry season. The reverse is the case on the south-east and east coast and in the interior generally. In these regions winter is the dry season, and on the coast summer is the rainy season. In the uplands of the interior summer cannot be termed exactly a rainy season; but what rain there is falls mostly then, and in the form of thunderstorms.

The climate of South Africa, while offering these broad distinctions for different regions, shows but little variety from place to place in the same district. In climate the Northern Karroo differs from the Central and from the Southern Karroo chiefly in having a higher mean temperature as well as a greater range of temperature. The higher mean temperature is due to greater nearness to the Equator; the greater range of temperature to the higher elevation. Throughout all these elevated regions the air is extremely dry. Unfortunately they are all liable from time to time to

dust storms; and the dust in many places, like Johannesburg, is apt to be largely contaminated with the refuse of the city.

The following tables show the chief meteorological features of three coast towns—Cape Town, Port Elizabeth, and Durban, and of one high-lying place in the interior—Bloemfontein. The data are taken from Samler Brown's admirable *Guide to South Africa.*

The sanitary arrangements are, as a rule, bad. Only in a few instances is there a good water supply free from pollution. Great efforts have, however, been made in recent years to secure a better organisation of the Health Department. It is to be hoped that a Central Board of Health may soon be established, and that the district surgeons may be appointed medical officers of health. The death-rate is abnormally high in spite of the magnificent climate. In the absence of a system of compulsory registration, exact figures cannot be given. In the Annual Health Report for 1892 the mortality of all races at Cape Town is placed between 24 and 25 per thousand. At Kimberley for the same year the death-rate was 35·38 for the European population, and 55·27 for the coloured races. Mining accidents, however, are responsible for part of this shocking mortality. Throughout the whole of Cape Colony typhoid fever is prevalent, and epidemics of diphtheria are not uncommon. An imperfectly described fever of remittent type, known as "Cape fever," "typho-malarial fever," "African typhus (or typhoid) fever," occurs in many districts; and is often fatal. Pneumonia and pleurisy, according to Davidson,[1] are probably as common in the Cape as in other parts of the world, while bronchitis is rare and mild. Rheumatism, acute and chronic, and neuralgic affections are very prevalent throughout the whole of South Africa.

The best time to arrive in South Africa is April, that is, at the beginning of the winter season—April to September. In this way one is not exposed to the great heat of the country until one has become to some extent inured to the climate. These same winter months are, however, also the

Cape Town Royal Observatory—2 miles from Coast, 40 feet above sea-level. S. lat. 36° 56′. E. long. 18° 29′. Observations taken at 8 A.M. (Samler Brown's *South Africa*, 1903-4, p. 62.)

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature (of max. and min.) | 70·6 | 70·4 | 68·4 | 63·0 | 58·2 | 55·5 | 54·0 | 54·9 | 58·0 | 61·0 | 64·4 | 67·7 | 62·2° F. |
| Mean daily range of temperature | 21·0 | 20·8 | 22·3 | 22·0 | 16·0 | 14·5 | 16·1 | 16·2 | 16·9 | 17·9 | 18·9 | 19·9 | 18·2° F. |
| Absolute range of temperature | 50·8 | 42·7 | 47·9 | 45·7 | 43·1 | 38·2 | 37·3 | 41·8 | 42·4 | 45·5 | 43·7 | 47·6 | 66° F. |
| Mean relative humidity . | 67 | 72·5 | 75 | 84 | 86 | 85·5 | 87 | 87 | 85 | 78 | 72 | 72·5 | 79 per cent |
| Rainfall in inches . . | 0·37 | 0·44 | 0·86 | 1·84 | 3·25 | 3·64 | 3·06 | 3·08 | 2·27 | 1·60 | 0·86 | 0·71 | 25·01 inches |
| Rainy days . . . . | 2 | 2 | 5 | 8 | 11 | 12 | 11 | 9 | 8 | 8 | 6 | 4 | 86 days |
| Cloud, 0-10 . . . . | 2·9 | 3·1 | 3·4 | 3·9 | 5·3 | 6·3 | 5·2 | 5·5 | 4·8 | 5·6 | 4·9 | 4·9 | 4·6 tenths |
| Mean barometric pressure corrected to 32° F. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 30·042 inches |

Port Elizabeth—S. lat. 33° 58′. E. long. 25° 37′. 181 feet above sea-level. Observations taken at 8 A.M. (Samler Brown's *South Africa*, 1903-4, p. 62.)

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature (of max. and min.) | 69·8 | 70·2 | 68·3 | 64·7 | 61·5 | 59·7 | 57·6 | 58·3 | 59·8 | 61·8 | 64·8 | 67·4 | 63·6° F. |
| Mean daily range of temperature | 11·8 | 12·0 | 12·8 | 14·1 | 15·7 | 16·9 | 17·8 | 15·5 | 13·3 | 12·3 | 12·3 | 12·3 | 13·9° F. |
| Absolute range of temperature | 30·4 | 25·4 | 28·1 | 36·0 | 35·5 | 39·2 | 36·8 | 43·0 | 37·2 | 36·1 | 39·2 | 27·2 | 49·2° F. |
| Mean relative humidity | 72 | 76·5 | 77 | 77 | 67·5 | 72 | 78 | 81 | 78 | 74 | 75·5 | 70·5 | 75 per cent |
| Rainfall in inches . . | 1·09 | 0·75 | 1·38 | 2·50 | 2·26 | 1·03 | 2·29 | 2·57 | 2·17 | 1·39 | 1·87 | 1·63 | 20·93 inches |
| Days on which rain fell . | 6 | 5 | 8 | 9 | 8 | 5 | 7 | 8 | 6 | 5 | 7 | 6 | 80 days |
| Cloud, 0-10 . . . . | 5·0 | 5·4 | 4·3 | 5·4 | 5·4 | 4·3 | 4·1 | 4·8 | 5·2 | 5·7 | 6·1 | 4·7 | 5 tenths |
| Mean barometric pressure corrected to 32° F. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 29·890 inches |

DURBAN—S. lat. 30° 4′. E. long. 29° 50′. 260 feet above sea-level. Observations taken at 9 A.M. (Samler Brown's *South Africa*, 1903-4, p. 69.)

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature (of max. and min.) | 76·3 | 75·7 | 76·9 | 69·5 | 66·8 | 65·3 | 63·6 | 66·7 | 65·8 | 68·9 | 72·8 | 72·6 | 72·4° F. |
| Mean daily range of temperature | 16·3 | 15·5 | 16·8 | 18·4 | 18·8 | 21·9 | 22·6 | 20·0 | 15·3 | 14·2 | 16·6 | 16·9 | 17·1° F. |
| Absolute range of temperature | 26·8 | 28·6 | 30·2 | 29·7 | 36·5 | 37·0 | 41·2 | 35·6 | 27·1 | 30·0 | 33·6 | 28·9 | 49·3° F. |
| Humidity, grains per cubic foot * | 7·5 | 7·6 | 7·7 | 5·8 | 5·3 | 4·7 | 4·4 | 5·1 | 5·2 | 6·1 | 6·9 | 6·6 | 5·95 grains per cubic ft. |
| Rainfall in inches . . | 4·74 | 4·70 | 4·53 | 2·51 | 1·81 | 0·92 | 1·51 | 2·14 | 2·77 | 4·07 | 5·25 | 4·53 | 39·48 inches |
| Days on which rain fell . | 11 | 14 | 9 | 11 | 11 | 4 | 3 | 7 | 21 | 22 | 20 | 19 | 152 days |
| Cloud, 0-10 . . . | 5·5 | 5·6 | 4·1 | 3·8 | 3·5 | 2·8 | 3·0 | 3·1 | 6·9 | 7·0 | 6·3 | 5·8 | 4·9 tenths |
| Mean barometric pressure corrected to 32° F. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 30·109 inches |

* To convert grains per cubic foot into grammes per cubic metre, multiply by 2·29. To convert grammes per cubic metre into grains per cubic foot, multiply by 0·44.

BLOEMFONTEIN—S. lat. 29° 7′. E. long. 26° 13′. 290 miles from coast. 4518 feet above sea-level. Observations taken at 9 A.M. 5 years. Maximum and minimum 15 years. (Samler Brown's *South Africa*, 1903-4, p. 68.)

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature (of max. and min.) | 72·5 | 71·8 | 72·0 | 60·0 | 52·2 | 47·6 | 46·8 | 51·7 | 58·7 | 64·4 | 68·2 | 71·1 | 61·0° F. |
| Mean daily range . . | 27·6 | 26·4 | 26·4 | 28·9 | 30·9 | 33·5 | 35·2 | 34·7 | 33·6 | 32·9 | 30·4 | 29·9 | 30·9° F. |
| Absolute range . . . | 44·8 | 42·1 | 49·0 | 48·3 | 48·9 | 48·4 | 51·8 | 55·4 | 55·0 | 53·0 | 53·8 | 49·0 | 74·1° F. |
| Mean relative humidity . | 54 | 56 | 75·5 | 68 | 64 | 61 | 65 | 58 | 53 | 49 | 46 | 52·5 | 58·5 per cent |
| Rainfall in inches . . | 2·13 | 2·74 | 5·16 | 2·49 | 1·51 | 0·25 | 0·42 | 0·97 | 0·99 | 1·62 | 0·69 | 2·32 | 21·29 inches |
| Days on which rain fell . | 8 | 8 | 9 | 8 | 4 | 2 | 3 | 3 | 3 | 6 | 4 | 8 | 66 days |
| Cloud, 0-10 . . . | 2·7 | 2·4 | 3·2 | 3·0 | 3·0 | 1·6 | 1·5 | 1·9 | 2·5 | 2·6 | 2·4 | 2·7 | 2·5 tenths |
| Mean barometric pressure corrected to 32° F. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 25·599 inches |

rainy season on the south-west coast, at Cape Town, for example; but the rain is neither so frequent nor so heavy in April as it becomes later. In Port Elizabeth the rainfall, though greatest during these same winter months, is more equally distributed throughout the year. In Durban the winter—April to September—is the dry season, and this is the case also in the high land in the interior generally, in Cape Colony as well as in the Orange River Colony and Transvaal.

If one wishes to avoid wet weather the best chance of doing so is to land at Cape Town, if one arrives in April; to land at Port Elizabeth, if one arrives in May; and to land at Durban if one arrives in June or later in the season.

The railway journey to the high-lying ground of the interior is shorter from Port Elizabeth or from Durban than from Cape Town. In Natal the variety of climate from the coast inland is much greater than elsewhere in South Africa.

In regard to the cases suitable for South Africa two or three points have to be borne in mind. Living is expensive; accommodation is poor, as a rule, except in the large centres; and food is bad. Milk is imported largely from Switzerland; butter is obtained from Norway and Sweden; and eggs are got from Australia. The country, therefore, is suitable only for persons who can "rough it," and who either have independent means or a certainty of employment. As changes frequently occur in the accommodation and medical attendance to be had in the various South African resorts, patients would do well to take advice on arrival as to the most suitable place up-country.

The ailments for the relief of which South Africa is visited are almost exclusively pulmonary; and of these consumption is the chief. The cases that do well are for the most part the same as those that get on well at high altitudes elsewhere. A fair amount of vitality is necessary, a certain vigour of the circulation, and a sufficient reserve aerating space in the lungs. A tendency to slight hæmoptysis, such as frequently occurs in the early stages of

phthisis is not a contra-indication; but the copious hæmorrhages that occur from cavities in the later stages of the disease are unsuitable for the highlands of South Africa, as indeed they are for high altitudes elsewhere. Febrile cases, as a rule, do badly in South Africa. The most suitable patients are cases of incipient tubercle without pyrexia in persons of otherwise fairly vigorous constitution, and cases in which the disease tends to assume a chronic form. For tubercular diseases of the larynx the dust and the excessively dry air are apt to prove irritating.

To young men suffering from slight chronic lung disease the country offers great advantages. Patients of this class can often earn their own livelihood, while the climate enables them to keep their disease at bay or even to subdue it entirely. At the same time no one should go out without means. After a while one may get work; but there is often difficulty at first. Those who are under no necessity to work for a living can usually do as well, if not better, at some of the European or American health resorts, where the comforts of life are more easily obtainable.

For those who have no occupation and no resources in themselves South Africa is a dull place, except in its large centres such as Johannesburg, Cape Town, and Durban. Those who have a taste for sport will have no difficulty in getting very fair shooting. There is little in the way of light amusement to be had, and there is not much stimulus to healthy mental occupation.

The great heat of the summer months, especially December, January, and February, is trying to many persons, though the fall of the temperature in the evening gives a freshness to the air, which prevents the enervating effects which are apt to occur in an equally warm but less dry climate.

The elevated country forming the eastern portion of Cape Colony is rather more suitable for invalids than is the western portion. Amongst the best places in the Eastern Uplands are Middelburg, at an elevation of 4200 feet above sea-level, and Cradock, at an elevation of 2856

feet, both in the Northern Karroo, and Aliwal North, at an elevation of 4350 feet, in the north-east of Cape Colony. The district surgeon, Dr. Morgenrood, speaking of the climate says:[2] "During the summer months the heat is often very great during the day, but the nights are generally cool; during winter the nights are often frosty, the temperature falling from 2 to 8 degrees below freezing-point, Fahrenheit. January, February, March, and April may be considered the chief rainy months, during which time thunderstorms often prevail, accompanied by heavy rainfalls and sometimes hailstorms." In the western portion of the Central Karroo Matjesfontein, 2970 feet, and Beaufort West, 2850 feet above sea-level, are also much resorted to. Ceres in the south-west district of Cape Colony lies at an elevation of 1493 feet above sea-level, and is ten miles, over a picturesque mountain pass, from the railway station at Ceres Road. It evidently formed part of the basin of a lake in former days. The summer months are apt to prove more enervating in the western districts generally than in the eastern districts. The dust, too, is usually more abundant and more trying in the west.

Bloemfontein, the capital of the Orange River Colony, 4518 feet above sea-level, is a favourite resort for consumptives. It is a pretty little town with rather a smart appearance. The streets are wide, and the houses with few exceptions one-storied. Fine public buildings give a somewhat metropolitan look in comparison with the village-like air of most South African towns. Trees, chiefly eucalyptus and willow, impart a fresh and green aspect to the dusty streets. The town occupies slightly undulating ground; and a few hills in the vicinity break the monotony of the wide expanse of plain. The country has a much less barren aspect than has the Karroo. Grass, parched and withered though it is during the dry season, clothes the soil in abundance when the rain comes on. One is glad to notice the absence of the scattered bushes by which alone the Karroo is relieved from the appearance of a desolate wilderness. Wheat and oats thrive; and the lemon tree as well

as the orange, flourishes. The winter season—April to September—is the best. The air is then dry, and little or no rain falls. As a rule there is little wind, but occasionally there are dust storms. They occur chiefly in spring—October and November. In summer, especially in January, the heat becomes oppressive in the town; but on the veldt, especially on somewhat higher ground, it exercises a less enervating effect.

In some marshy districts in the neighbourhood malaria, though rare, sometimes occurs. Typhoid fever, rheumatism, acute and chronic, and neuralgic affections are common here as elsewhere in South Africa. Patients visiting Bloemfontein for health do well to leave the town as soon as possible for suitable quarters on a farm.

Johannesburg, which in 1887 consisted of only a few camp tents in a treeless country, is now a large town with good streets and fine buildings and shops. Trees are now fairly abundant, and well-grown plantations are seen in various places around the town. Tastefully arranged gardens add to the agreeable aspect of the suburban houses. Orange and lemon trees grow satisfactorily. Tobacco also is cultivated.

Johannesburg, 5689 feet above sea-level, is built on more or less uneven ground; and the Rand, the mountain ridge from which the town derives its wealth, cuts the landscape with a bleak, hard outline, welcome as a contrast to the monotonous flatness of the country in general.

The soil consists of a sticky red sand, which during the dry season is whirled about by the wind with the dust of the city refuse and of excrementitious matter generally. The air of other South African towns and villages is commonly polluted with the same kind of organic matter; but the evil is worse in Johannesburg, owing to the larger population. As might be expected, pneumonia of a severe type is very common and, not infrequently, fatal.

The water supply is not very satisfactory. Closet excreta are removed by the bucket system usual throughout South Africa.

All the diseases due to lack of sanitation are rather prevalent. Typhoid fever is common. Dysentery appears from time to time. Diphtheria is not infrequent. Malaria is said to occur when ground is broken for the first time.

In spite of all these drawbacks many phthisical patients have regained their health in Johannesburg; and, taking an active part in the business life of the place, have at the same time earned a livelihood or even have built up a fortune.

Amusements and recreations are provided in great abundance.

Pretoria, the capital of the Transvaal Colony, is forty-six miles by rail and thirty-two miles by road from Johannesburg. It lies at an elevation of 4471 feet above sea-level; and is therefore 1218 feet lower than Johannesburg. It is situated in a valley, surrounded by low hills. Trees, chiefly blue gum and willow, relieve the nakedness of the landscape. The soil consists of a sticky red sandstone, which adheres with great tenacity to clothes.

Sanitary arrangements are primitive, as elsewhere in South Africa. The diseases prevalent are much the same as in Johannesburg, and are for the most part due to neglect of hygienic precautions.

The climate of Pretoria, while much the same in general features as the climate of Johannesburg is milder, less windy, and less dusty in winter; while in summer it is much hotter and more relaxing.

Amusements are few; commercial enterprise is almost stagnant; and compared with Johannesburg the city may well be termed a sleepy hollow.

Natal shows the same terrace or stairs formation as Cape Colony, though not with such precision or regularity. The low-lying portions of the country in the neighbourhood of Durban have a distinctly tropical appearance. As the land rises rapidly inland by hill after hill the vegetation gradually indicates a less and less warm climate. The great luxuriance of vegetation and the numerous watercourses give evidence of considerable moisture until the

highest levels are reached. The broken irregular country with its varying and abundant vegetation, rich in fruit, in foliage, and in crops, renders the railway journey between Durban and Charlestown one of the most beautiful that can be imagined—a delightful contrast to the dreary expanse of veldt that meets the eye from the railway line elsewhere in South Africa, with one or two exceptions.

With all its beauty Natal is not quite so suitable as a place of residence all the year round for phthisical patients, as are its less picturesque neighbours. Durban has a fairly cold and crisp winter season from April to September; though even during this, its dry season, an occasional heavy downpour with a thunderstorm is by no means infrequent. The summer or wet season, from October to March, has been likened to a steam bath for heat and for moisture.

Pietermaritzburg, the capital of Natal, about seventy miles by rail, but little more than forty miles in a direct line, from Durban, lies at an elevation of 2220 feet above sea-level. It has a more bracing winter season than Durban, but is not high enough to escape the heat and moisture of summer.

Howick, at an elevation of 3439 feet, an hour and a quarter by rail from Pietermaritzburg, has a sunny and bracing winter season; but in summer is exposed to mist, rain, and high winds.

Estcourt, at an elevation of 3833 feet, also on the railway line, is one of the best resorts in Natal for pulmonary ailments. Dr. Bonnar of Durban, quoted by Dr. Fuller[3] in his excellent little work on *South Africa as a Health Resort,* says: "Estcourt, being in the midst of one of the finest farming districts of Natal, cases are not uncommon where invalids, being so far benefited or restored by its charming climate, have been induced to remain in the locality, and themselves embraced successfully a farmer's life. In the village good accommodation is afforded at the several substantial hotels, and for patients requiring special attention arrangements can be made. In a wonderfully dry and invigorating atmosphere, markedly free from dust, the patient has a perfect climate during the greater part of

the year; but Dr. Brewitt (of this town [Estcourt]) advises a change 'overberg' to the Free State [Orange River Colony] especially during January, when a temperature and atmosphere similar to the Estcourt cooler months are obtained. Such a change is easily effected, Estcourt being but seven hours by rail from Harrismith in the Orange Free State. He advocates further a change to the coast during June and July for those who prefer a greater amount of warmth than is present in the clear and cold up-country mornings and evenings during the winter season."

Food and accommodation are on the whole much better in Natal than elsewhere in South Africa.

One of the highest, if not the highest, of inhabited places in South Africa is Wakkerstroom, 5900 feet above sea-level. It is in the Transvaal Colony, just over the northern boundary of Natal. It lies eighteen miles from the railway line at Volksrust, a journey of three hours by cart.

At Kimberley—not itself a health resort—in Cape Colony there is an excellent sanatorium for consumptives.

REFERENCES

1. Davidson, *Geographical Pathology*, vol. ii. p. 656.
2. *Reports on Public Health*, Cape Town, 1893, p. 66.
3. A. Fuller, *South Africa as a Health Resort*, London, 1892, p. 56.

# CHAPTER XVI

## ALGIERS

Algiers is situated on the southern shores of the Mediterranean, lying in almost the same latitude as Palermo, but a little further south. The town is beautifully situated on the slope of a hill, facing the east. The population is about 100,000.

Algiers belongs to the same large group of health resorts as Madeira, and is usually considered to occupy a position midway between Funchal and Cairo, being moister than Cairo and drier than Funchal.

The meteorological observations supplied by different observers do not afford a very precise idea of the character of the climate. From the meteorological tables alone great equability both of temperature and of relative humidity might be inferred. As a matter of fact, both temperature and humidity are liable to very sudden and unexpected changes. A not infrequent occurrence early in winter is a sudden fall of temperature with a considerable increase in the amount of moisture. Such changes are most frequent in the afternoon between four and five; and a couple of hours later the temperature in the same place may have gone up considerably again. These alternations in temperature are due chiefly to irregularity in the winds. The wind during the daytime of the winter months blows most commonly from the sea, either as an east, north, or north-west wind. From the west winds blowing over the land the town is fairly well protected by hills. The scirocco, or hot wind from the desert in the south, blows chiefly in summer,

but occasionally also in winter. This wind, in addition to its oppressive heat, carries with it a fine, reddish dust, from which there is no escape.

Algiers when first occupied by the French quickly acquired an evil reputation, owing to the high rate of mortality in the army. With the many improvements in sanitation introduced by the new occupiers the health of the town improved greatly. The rate of mortality is still high, and phthisis is a comparatively frequent cause of death in the large towns—a fact mainly due to the number of persons affected with the disease who visit the country for their health. Malaria, though common in the country, is rare in Algiers itself. Bronchitis, acute and chronic, and also pneumonia are more frequent, according to Davidson, than in either France or England.

From the foregoing account it will be seen that Algiers is hardly a place of resort for people disposed to catch cold readily. Such patients are very apt to be troubled either with rheumatic affections or with recurrent bronchial troubles. Patients of a robuster class, not easily influenced by brusque variations in heat-demand, frequently do well in Algiers. The picturesqueness of the scenery and the great variety of interest in an Eastern town render it a useful place of resort for patients in need of mental recreation.

Algiers has the reputation of being "bad for the liver"; and in many instances the digestion is readily upset there.

The sudden variations in heat-demand, due to changes in temperature, wind, and moisture, render the place unsuitable for albuminuric patients.

Hammam R'Irha, about three hours by rail, followed by a carriage drive of an hour and a quarter from Algiers, is a large hotel at an elevation of 1900 feet. It has hot saline springs, which are useful as baths in rheumatic and allied affections. It has also a cold chalybeate spring, the water of which is taken with advantage in anæmia.

The country about Hammam R'Irha is beautiful. Owing to the altitude the change from Algiers in warm weather is very refreshing.

Biskra is situated on the border of the desert, about thirteen hours by rail from Philippeville. From Algiers the journey takes the best part of two days, the night being spent at Constantine.

Biskra has a very dry climate, but is colder in December, January, and February by three or four degrees Fahrenheit than Algiers or Cairo. It is also subject to strong winds from the north. Like other places close to the desert it is liable to occasional dust-laden winds from the south.

Biskra is suitable rather for valetudinarians than for invalids. For Europeans it can hardly compete in attraction with the Egyptian resorts, such as Assouan, Luxor, Mena House, or Helouan.

# CHAPTER XVII

## MADEIRA AND THE CANARY ISLANDS

MADEIRA is a small island belonging to Portugal—situated 350 miles off the north-west coast of Africa, and about four days' journey from Southampton. Its exact position is 32° 43′ N. latitude and 17° W. longitude. It lies somewhat farther north than the north coast of Egypt. The island is about 30 miles in length from west to east, and about 12 miles wide from north to south. It is of volcanic origin, and the ocean which surrounds it is of great depth. Though the country is rocky the vegetation is of the richest description. The vine formerly flourished in abundance, yielding the well-known Madeira wine. For some years this plant suffered from the disease that caused so much ravage in wine-producing countries generally; but in recent years through the assiduous use of sulphur the disease has been checked. When the wine industry began to fail the cultivation of the sugar cane was introduced. The air is very free from dust, owing to the basaltic formation of the ground. An exception to this rule occurs when the "leste," a hot wind blowing from the African desert, the Sahara, sweeps across the country, carrying with it extremely fine dust, and sometimes even locusts and small birds from the neighbouring continent.

The population of the island in 1900 was 134,000; and of Funchal, the chief town, nearly 19,000.

Since Madeira was first really known to Europeans in 1418, it has always been regarded as a kind of earthly paradise. The beauty of its scenery and the charm of its

climate have always stamped it as a delightful spot to live in. The very circumstances which have created these advantages have to a large extent prevented people from making use of them. The warm yet temperate climate of the country is due to its insular position, a long way south of Europe, involving several days' journey by sea.

Funchal, the capital of Madeira, is beautifully situated on the south coast of the island. It is surrounded by mountains in the form of an amphitheatre, about 5200 feet high, protecting the town from north wind.

The climate of Funchal has been the subject of much discussion. It is usually regarded as the most equable that exists; though the south-west coast of England has probably a better claim to this merit—if merit it be. The meteorological records of different observers have yielded more or less discordant results as to temperature, relative humidity, the number of rainy days, and the amount of sunshine. The discrepancies in observation are due to several causes, but chiefly to the defective instruments and to the different posts and hours of observation chosen. The usual hours for meteorological observation in Madeira and the Canary Islands are 9 A.M., 3 P.M., and 9 P.M.; but in some places observations are made only at 9 A.M. and 9 P.M.; and in one place (Santa Cruz, Teneriffe) at 11 A.M. and 5 P.M. The results, therefore, are not comparable with each other or with the records at modern stations. All observers are fairly well agreed as to the mean temperature of the climate, which is about 67° F. for the entire year, 61° for winter, and 70° for summer. Differences of opinion begin to show themselves in regard to the equability of the temperature. Remarkably little difference exists between the mean temperature of winter and of summer; and the daily variation of temperature is said by some writers not to exceed 7° to 9° F. Other observers place it at from 10° to 11° F., and one careful observer (Coupland Taylor) gives the mean daily range of March and April as 12·7° F.

To a still greater extent has the relative humidity of the air been a point in dispute. By many writers Madeira has

been ranked amongst the most humid, the mean water-vapour in the air being estimated at about 80 per cent of the possible amount. According to the official meteorological records, the mean relative humidity varies from 63·4 to 69 per cent in the eight months October to May, from which it would seem that Funchal is drier than Cairo, at least during December, January, and February. The records from the two places in parallel columns for these months show this at a glance.

RELATIVE HUMIDITY

| | Funchal.[1] | Cairo.[2] |
|---|---|---|
| December . . | 68·2 | 69·6 |
| January . . . | 69·0 | 69·7 |
| February . . . | 66·0 | 66·2 |

These figures may well teach us not to put our faith in meteorological tables. The Funchal statistics are based on observations at 9 A.M. and 9 P.M.; the Cairo figures on observations at 6 A.M., 9 A.M., noon, 3 P.M., 6 P.M. 9 P.M., and midnight. Dr. Grabham places the relative humidity in winter between 75 and 78. The number of days on which rain falls varies considerably from year to year, ranging from 45 to 102. From 70 to 80 is the usual number, and these occur mostly from October to March.

The sky during the day is rarely free from clouds, which moderate largely what would otherwise be the oppressive heat of the sun. A certain amount of wind blows almost constantly. The sea breeze and the land breeze alternate with great regularity; and the wind is rarely strong enough to be unpleasant, though sensitive invalids complain of the cold blasts that come down through the mountain ravines. The north-east wind blows almost constantly over the island, but, as already said, the mountains at the back of Funchal protect the town from its influence.

The general health of the natives of the island is fairly good, especially among the men, who for the most part lead

an out-door life. The women, however, who are much confined to the house, suffer greatly from phthisis. This is hardly surprising when the wretched condition of their hovels is taken into consideration. The dwellings are mostly damp and ill-constructed, without proper ventilation or light. Another ailment common to the country is diarrhœa, due probably to defective water supply.

The merits of Madeira as a health resort have been the subject of even more contention than has been its climate. By our ancestors Madeira was regarded as the most favourable climate for the consumptive. For a time it fell into disfavour, and was considered of all places the most prejudicial. At present it is to some extent regaining not indeed its old position, but a modified degree of favour both with the profession and with the public. This oscillation of opinion has been due to the lack of any well-defined principles in regard to the choice of health resorts.

Sir James Clark, with whom Madeira held a place of high honour for its benign influence on the course of phthisis, lays down rules of guidance. He quotes certain tables from Dr. Renton, who for years practised in the island, tending to show that the cases pre-eminently suited for the place were those of incipient phthisis, while advanced cases, though their discomfort might be alleviated, were rather more likely to be injured than helped. In our days the tendency is to send to Madeira not incipient cases, but cases in a hopelessly advanced stage, the intention being avowedly not the hope of curing the disease, but of lessening the suffering that the patient would otherwise have to endure. I have no hesitation in saying that both of these principles are absolutely unsound, and cannot fail in many instances to lead to disastrous results. A certain proportion of patients advised in accordance with those unsound principles may indeed reap all the benefit that was expected. On the doctrine of chances they could not all be expected to do badly. But the result is a matter of luck.

A considerable number of patients have passed through my hands who wintered at Madeira either before or after

being in Davos; and in some instances a season in Funchal was spent between two seasons in the Swiss mountains. My observations on these patients confirm the principle that I have already more than once laid down, that in regard to the choice of climate in tuberculosis the stage of the disease, and even the extent of it, are comparatively unimportant; and that the chief condition which determines the fitness of a certain climate for a certain patient is the capacity for tissue change, and the general power of nutrition in the patient. The climate that offers the greatest likelihood of improvement or of arrest in early phthisis and of alleviation in advanced phthisis is that climate where the patient's nutrition is at its highest level; and this highest level is secured in a cold climate to one patient of high assimilative capacity, while it is secured in a warm climate to another of feeble nutritive power. In any case the climate that makes that demand on the assimilative powers generally to which the organism can best respond is that which will secure the highest resistive power to tubercular disease.

The chief indication, then, that Madeira is the most suitable health resort for a patient is the lack of power of response that would be required in a colder climate. Amongst the few local conditions that influence the choice of a health resort is the state of the mucous membrane of the air passages. An irritable condition of the larynx, for example, or of the bronchial tubes, attended with scanty secretion, is likely to be soothed by warm air containing a considerable amount of moisture, while exceedingly dry air, whether warm or cold, tends to heighten the irritability. Sometimes, however, such a condition of the mucous membrane is not simply a local condition, but is the expression of a disordered state of the system generally. Gout, for example, frequently gives rise to such catarrhal inflammation. In cases of this kind, the general health is of primary importance; and not infrequently a dry climate, though at first it may seem to irritate the inflamed membranes, will, by improving the general health, indirectly aid in removing the morbid process.

In such cases the most bracing climate a person can stand is the most suitable to get rid of the underlying morbid condition, while a more humid or so-called relaxing climate will best help to cause the disappearance of the remote effects of the disease.

Bright's disease does well as a rule in Madeira, though the disease is not unknown amongst natives.

Patients with a tendency to diarrhœa should avoid Madeira.

For rheumatic and gouty people Madeira may or may not be suitable. In their case, as in the case of the tubercular, the general constitution is of more importance than the local condition. The rule in such cases should be to choose the most bracing climate that the patient's system will respond to. This is the broad rule; but in any case irregularity or variability of weather is a distinct drawback in such ailments, and whether a cold or a warm climate is selected, regularity of weather as distinguished from equability is to be sought for.

Another class of case in which the climate of Madeira is suitable is that of old persons who have difficulty in withstanding the cold and the changes in temperature that occur in a more northern and moist climate.

Overworked business men also occasionally find Madeira a suitable place of resort, its moist warm air tending to diminish the wear and tear of nerve force.

In former years Madeira was resorted to much more largely than in our days. Formerly the winter population of invalids would amount to 500; two-thirds of that number would probably represent the present winter population, and of these about two-thirds are English.

In regard to food, vegetables, and fruit, Madeira stands in the first rank of health resorts. Its hotel accommodation is good, and the landlords are noted for their civility and for their attention to the requirements of invalids. Private apartments are rather expensive and leave much to be desired in regard to sanitary arrangements.

## THE CANARY ISLANDS

The Canary Islands are about 220 miles south of Madeira and 60 miles off the African coast. For the last twenty years or so these islands have grown in favour as a place of resort for the winter. Orotava in the island of Teneriffe and Las Palmas in Grand Canary have especially become popular. Guimar and Tacoronte, both in Teneriffe, have lately begun to develop as health resorts, and offer the advantages of moderate elevation, the hotel at Guimar being 1200 feet and the hotel at Tacoronte 1700 feet above sea-level. Monte, also not far from Las Palmas in Grand Canary, has an altitude of more than 1300 feet, and affords a refreshing change from Las Palmas.

The climate of the Canary Islands is nearly the same as that of Madeira, but is two or three degrees warmer and rather drier. The Canary Islands have more wind, and, unlike Madeira, are not free from dust. The coldest months of the year may be regarded roughly as ten degrees warmer than on the Riviera and twenty degrees warmer than on the south coast of England, or as having about the same temperature as the summer months in the south of England. The high-lying resorts afford an escape from the heat of summer. The Canary Islands and Madeira thus belong to the not very large group of health resorts adapted for permanent residence, where an invalid can live with advantage the whole year round. These islands, especially Teneriffe and Grand Canary, present a sufficient variety of climates to afford adequate change for the majority of persons for whom the climate in general is suitable. Samler Brown says: "Fine as the climate of Madeira and of the Canaries may be in the winter, it is infinitely finer and more enjoyable in the summer."

It may be added that openings for the investment of capital under personal supervision are probably still to be had.

Las Palmas in Grand Canary is drier than Orotava in

Teneriffe, but is by no means free from dust. In freedom from dust Orotava probably comes up to Funchal.

Water supply and drainage in the Canary Islands, as in Madeira, are considerably short of perfection.

The Canary Islands are suitable for the same types of invalid as is Madeira; being drier, however, and offering a greater variety of climates, they are generally preferable.

### REFERENCES

1. Brown's *Madeira, Canary Islands, and Azores*, 1903, p. *e* 1.
2. *Egypt as a Winter Resort*, by F. M. Sandworth, 1889, pp. 25, 26.

# CHAPTER XVIII

## THE MEDITERRANEAN

A FEW words may be said concerning the influence of the Mediterranean as a modifier of climate in the adjacent countries.

The Mediterranean is of great depth—5000 to 10,000 feet, and in some places nearly 12,000 feet. The colder water of the Atlantic is to a large extent shut out by a barrier at the Strait of Gibraltar coming to within 1000 feet of the surface. At the Dardanelles a higher barrier, coming to within 120 feet of the surface, helps to keep out the cold waters of the Sea of Marmora and of the Black Sea. This immense basin receives only four great rivers, the Ebro, the Rhone, the Po, and the Nile; but the water supplied by these streams and by rain is not enough to replace what is lost by evaporation, the mean level of the Mediterranean being about 2 feet lower than that of the Atlantic.

As a consequence of these conditions the temperature of the water is comparatively high, and at depths below the level of the Gibraltar barrier almost uniform—about 54° F. to 56° F. The surface water near the shore has a temperature in winter four or five degrees higher and in summer only three or four degrees lower than the mean air temperature of the season over the adjacent land.

The high temperature favours low barometric pressure over the water. The low temperature and high barometric pressure over the elevated plateau of Spain and of France, and over Central Europe, combine to furnish north winds over the greater portion of the northern shores of the Mediterranean in winter. Along the French Riviera the

general tendency is supplemented and intensified by local conditions. The strip of ground between the sea and the mountains becoming strongly heated by the sun, attracts still more the cold air on its way from the mountains to the warm sea.

Below Genoa to half-way down the west coast of Italy the predominating wind in winter is the north-east, and over the lower third the south-west wind. Along the south-east coast of Spain and along the northern coast of Africa the wind blows mainly from the west, with a slight inclination from north or south according to circumstances. In North Africa the barometric pressure tends to be lower from the coast to the equator than over the Mediterranean; and in Egypt the prevalent winds blow from the north the whole year through.

The rainfall all over the Mediterranean basin occurs chiefly in winter.

### The Riviera

The stretch of land between Hyères and Genoa on the northern shore of the Mediterranean Sea has for many years afforded numerous winter health resorts to the English and to other nations. The reputation of this coast land is not undeserved. Its position on the borders of a great inland sea lying close to the sub-tropical regions secures for it a high degree of warmth. The same mean temperature in the coldest month extends from Toulon to Naples; and the oscillations in temperature are comparatively small. In addition to the neighbourhood of the sea, it has the good fortune to be protected on the north more or less perfectly throughout its entire extent by a range of mountains. In places entirely unprotected by mountains this northerly wind, which is cold and dry, blows almost constantly and at times with great fury. In well-protected districts it is perceived only when reinforced by the general winds of the country blowing in the same direction. This northerly wind—more strictly speaking, north-west wind—is known as the mistral—the word meaning magistral or master wind.

The greater or less protection from this wind is the main feature that determines the value of different points along the coast as health resorts for invalids. Other winds indeed blow, the south-east wind especially, from time to time in a very unpleasant manner; but the discomforts arising from the other winds are of comparatively small account.

Another feature greatly affecting the value of the Riviera for invalids is the dust, due to the limestone formation of the soil. The annoyance from this source is especially noticeable when the mistral is blowing.

Apart from these two serious drawbacks, the climate along the whole coast of the Riviera is found by most people to be charming. The temperature in winter is about that of spring or early summer in England; the number of rainy days is only about half as many as at our South Coast stations; and the sky is of a transparent blueness quite unlike what we are familiar with in the more humid climate of the British Isles. When to this is added the boldness of the scenery, the variety of trees and flowers, and the lovely waters of the blue Mediterranean, there is little ground for surprise that visitors from the harsher climates of the north come in numbers to pass the winter on these favoured shores. The visitors consist not merely of invalids, who seek to escape the catarrhs and rheumatism that haunt the more northern countries, but of valetudinarians—old people and people in weakly health, who by avoiding fogs and damp are enabled to enjoy health and outdoor life, whereas at home they would be invalids or prisoners in their own rooms.

The general health of the whole district is fairly good, in spite of sanitary arrangements that are still far from perfect. The arrangements, however, in the better class of hotels are as a rule satisfactory.

Hyères, Cannes, Mentone, and San Remo are all supplied with excellent water coming from a distance. The prevailing system of drainage is by means of the cesspool.

Epidemic diseases are not more frequent—perhaps less frequent and less severe—than in England. Typhoid fever

shows itself from time to time in most of the Mediterranean coast stations. Diarrhœa, too, is a rather prevalent ailment. It does not appear, however, to be of specific character, and is probably due partly to the heat and partly to the food.

Rheumatic ailments, in the strict sense of the word, are not very common, but muscular rheumatism and "rheumatic pains" are rather prevalent, as is also neuralgia in various forms. Catarrhs, nasal, pharyngeal, laryngeal, and bronchial, are frequent along the whole coast during the winter, especially in places much exposed to the mistral. Whether they are more or less prevalent than in England is a doubtful point. Seeing, however, that many people subject to winter bronchial catarrh escape their ailment altogether by passing the cold season on the Riviera, the presumption must be that the liability is less.

As to nervous diseases. It has already been remarked that neuralgic ailments occur with much frequency. In addition, the tendency to hysterical outbreaks is said to be greater on the Riviera than farther north. Many people find the climate too exciting—an influence showing itself by sleeplessness and by increased irritability. The climate is thought by some to predispose to cerebral hæmorrhage; but this view is decidedly open to question. The brilliant sun may no doubt give rise to heat-stroke.

The so-called exciting action of the air is wholly and solely a question of personal reaction: what is exciting to one person is relaxing to another.

We will now examine in detail the different winter stations of the Riviera, and place their salient points in contrast.

In a general way it may be stated that more complete shelter is offered from cold winds by the stations at the eastern end of the Riviera di Ponente—Mentone standing pre-eminent amongst these.

### Hyères

Hyères is a town of about 15,000 inhabitants, and is the most western of the health stations on the south coast

of France. Its characteristic feature, as distinguished from the other resorts of this group, is that it lies not on the sea, but three miles inland. Two ranges of hills on opposite sides protect the town respectively from the north-east wind on one side and from the east and south-west winds on the opposite side, but leave it freely exposed to the cold north-west and to the south-east winds. In fact, the mistral blows with greater frequency and violence in this region than in any other station along the coast.

The number of rainy days is about 37 to 40 in the months from November to April. Fogs occur from time to time in spring and in autumn. The mean relative humidity of the air at Hyères has not as yet been the subject of trustworthy observations. 58 per cent is the amount that has been given in some observations taken with August's psychrometer. Probably a relative humidity of 70 per cent would more nearly represent the mean state of the atmosphere.

The water supply in Hyères is good, and the sanitary condition of the hotels is probably as good as anywhere else along the Riviera. The town, like most of its neighbours, is "smelly." The cesspool system is in use here as elsewhere along the coast.

Costabelle, about two miles south-west of Hyères, is warmer and much more sheltered from cold winds.

Since the sixteenth century Hyères has been celebrated for the mildness of its winter climate. Catherine de Medici wished to build there "a royal house surrounded with gardens"; and Queen Victoria spent the spring of 1892 at Costabelle. To a great extent, however, Hyères has been eclipsed by its rivals along the coast.

Hyères itself is too much exposed to the mistral to be advisable for invalids of a sensitive type; but Costabelle is better sheltered than most of the fashionable resorts on the Riviera.

In Reynolds Balls' *Mediterranean Winter Resorts* Dr. Biden, who has been in practice at Hyères for many years, gives valuable hints as to the cases that do well. Patients

with "marked nervous irritability usually have to be sent away, though some may prove amenable to treatment. . . . The Hyères climate is advantageous for the atonic and catarrhal forms of dyspepsia, chronic intestinal catarrh and chronic dysentery. . . . Neuralgia does well, but not so hysteria, hypochondriasis, and spinal irritation. It is well suited for cases of locomotor ataxy, but not cases where there is any tendency to cerebral congestion." He speaks also of favourable results in diabetes, gout, rheumatism, and renal ailments.

The general social character of the place is one of quiet and repose. For this reason, and on account of its distance from the sea, it is preferred by many persons who are in search mainly of rest.

### Cannes

The distinguishing feature of Cannes, in addition to the beauty of its situation and the charm of the country around, is the activity of its social life. Chosen, in 1834, by Lord Brougham as a place of winter residence, it rapidly gained the favour of the British travelling public, and has never since lost the impetus given by its distinguished visitor. Many people find the blue sky and the magnificent expanse of the Mediterranean, dotted in this place with a couple of small islands, a pleasant exchange for the cold and damp of an English winter. But the beauty of the scenery is not the only attraction. A round of gaiety and amusement, outdoor as well as indoor, serves the purpose of recreation. This feature of life at Cannes is by no means an advantage for all invalids, especially for those suffering from pulmonary ailments. Lawn-tennis by day, and dinner parties and dances by night, are not the pastimes for such persons; but when the temptation is at hand, comparatively few invalids of this kind have the constancy of purpose to forgo a momentary pleasure for the sake of a distant reward.

The temperature at Cannes is about one degree lower than at Mentone. For example, the mean temperature in

January is about 48° F. in Cannes; about 49° F. in Mentone. The divergent records of different observers hardly warrant a more precise statement. The mean number of rainy days in Marcet's observations was 45·6 in the six months from November to April—being somewhat more than at Nice (36) and at San Remo (29), and much the same as at Mentone (47). The mean relative humidity, according to Marcet, is 73 per cent, almost the same as that of Mentone (72·8). The relative humidity at Cannes for the same months, according to Dr. de Valcourt, is 62·16. Dr. Marcet's figures are probably the more trustworthy.

The daily range of temperature is about 12° or 13° F., a sharp fall occurring at sunset, when invalids are usually cautioned against being out. Some excellent authorities, however, consider that the evening air might be enjoyed without risk by delicate persons. But it is not customary amongst visitors to the Riviera to spend the evenings out of doors.

The special feature of the climate at Cannes, as distinguished from that of its neighbours, is its greater windiness, the mistral occurring more frequently than at the more eastern resorts. In addition to the wind, the dust is another great plague. The defect as regards the wind is, of course, irremediable, but much could be done to lessen the dust plague.

A third defect is the lack of sanitation in the close and crowded parts of the old town. However, the sanitation in most of the hotels is now generally in accordance with the requirements of the present state of sanitary science.

Here I may quote some observations by Dr. Marcet[1]:—"To sum up my remarks on the climate of Cannes, and, I may add, of the Riviera in general. In November and December the weather is usually stormy and wet. January and February are fine, with occasional visits of the dry north-east wind. During those two months the air is usually calm in the morning, with a pleasant light southerly breeze blowing in the afternoon, while a northerly land breeze commences at sunset and is continued during part of

the night. March and April are windy and showery, the winds showing no particular regularity, although in general easterly with wet weather.

"In December and January the nights are comparatively cold. The grass may be seen covered with hoar-frost in early morning, and a thin sheet of ice may form on the road puddles, but wherever the sun reaches, except under very exceptional circumstances, it is melted by noon. In certain places with a northerly aspect and screened from the sun, ice may remain all day, and even acquire a quarter of an inch in thickness in the coldest seasons. I have often observed the mud frozen and ice on the roads some little distance, say a quarter of a mile, from the sea; while the road was quite soft and there was no ice at all at the immediate seaside."

One of the points necessary for a visitor to Cannes is that he should have plenty of money. Of all the Riviera resorts it is the most expensive, except perhaps Monte Carlo. The hotels indeed are good, and the food is generally all that can be desired, but the prices are high.

Amongst the cases unsuitable for Cannes are neuralgias. Persons suffering from gout or from rheumatism, though probably better off than in England, are more under the influence of their ailment than in Mentone or in San Remo.

In regard to pulmonary tuberculosis, if the disease only is considered, Cannes, owing to its wind and dust, would hardly be so suitable as some of its rivals; but in this disease a large view of the case is essential. The disease must be regarded as a secondary affair in comparison with the general constitution; and from this standpoint many persons who find Mentone relaxing consider Cannes bracing. It must be added that others of a weaker fibre find Cannes irritating and depressing, and Mentone bracing. Besides these differences in personal reaction to climate, there remains the important question of mental occupation; and though we must not yield too readily to the importunities of patients not to be sent to dull places, it must be admitted that for many patients indiscretion in the way of over-

fatigue and amusements is a less evil than dulness, which leads to moping, and in the end to a general declension of health. There is little use in preaching the gospel of work and of mental activity to persons who have no resources within themselves and whose minds are too inane to be interested by anything but by outside attractions. The inanity of such persons must be taken as a fact, and allowed for in the advice given them. It thus often happens that a place which might be deemed absolutely the best for a given type of case in a given constitution does not fulfil its purpose owing to the uncongeniality of its surroundings. The gist of all this is that many persons will get on well at Cannes who would mope at one of the less lively resorts.

## Nice

Nice is the largest of the Riviera health resorts, being a town with close upon 100,000 inhabitants. In former days it held a much higher rank amongst the southern health resorts. Since other places have been made available for the winter residence of foreign visitors, the drawbacks of the Nice climate have become more evident. Though sharing with its neighbours the blue sky and the magnificent scenery, it is much more exposed to winds from all quarters, and to variations of temperature, than is any other winter station on the same coast. Complaint is made not merely of the prevalence of the mistral or north-west wind, but as an aggravation of annoyance even this wind, when it leaves off, is replaced by others almost as bad; and these changes in direction are so frequent that hardly any part of the district can be relied upon to afford sufficient shelter. Windiness is thus the prevailing climatic characteristic of Nice as distinguished from its neighbours. The temperature is much the same as that of Cannes, both in regard to its average amount and to its daily range. But the sudden changes in the direction and in the strength of the wind cause oscillations in temperature which are felt very keenly, though hardly noticeable by the thermometer.

The average number of rainy days in the six months from November to April is 36·2, according to M. Teysseire's record of 28 years.

The fact that Nice is a large town is an advantage or a disadvantage according to the nature of the case. For phthisical invalids the distractions of a large town are quite unsuitable, and for such cases the climate of Nice is perhaps the most undesirable to be found along the whole Riviera. For a certain class of hypochondriacs, and for persons of torpid constitution and not sensitive to the influence of wind, Nice is not merely invigorating but a pleasant place of residence.

The winter visitors are of a cosmopolitan character, all the nations of Europe being represented. The number of Russians especially is large. Society is said to be less exclusive there than in some of the adjoining resorts.

Catarrhs, pharyngeal and bronchial, are frequent. Pneumonia and pleurisy occur often in the spring. Rheumatic affections are not uncommon in autumn.

Beaulieu is a beautifully situated and well sheltered spot half-way between Nice and Monte Carlo. It is well protected, lying open only towards the sea. It is, as may be supposed, a much quieter place than its neighbours.

Monte Carlo is one of the most beautiful and most sheltered spots on the Riviera, and, but for the gaming tables, would be an admirable health resort.

### Mentone

Mentone is about 15 miles from Nice and $2\frac{1}{2}$ miles from the Italian frontier. For many years back it has been gradually assuming more and more importance as being the most sheltered portion of the Riviera. To the late Dr. Henry Bennet its rapid development is chiefly due.

The climatic advantages of Mentone are easily understood when the position of the town and of its protecting mountains is considered. The shore forms a semicircle, culminating at each end in a headland, while at the back of

the town the mountain range lies much closer than is the case in the neighbouring resorts. This disposition is especially marked at the eastern end of the town, where the advancing mountains leave only a narrow strip of ground between themselves and the sea. As a result of this arrangement the east bay of Mentone is not merely more sheltered from the wind, but it is two or three degrees warmer than the western extremity, the extra heat being due partly to the reflection of the sun's rays from the rocks, and partly to the yielding up at night of heat which had been absorbed during the day. The difference of two or three degrees in temperature, though in itself a comparatively small matter, is by no means an unimportant consideration when combined with the very important element of diminished air movement. The difference in temperature between the east and the west bay is almost greater than between the west bay and some of the neighbouring resorts.

The mean winter temperature of Mentone as a whole is about one degree higher than that of Cannes; the mean temperature of January, for example, is about 49° F. The number of rainy days, 47 for the six winter months, is probably nearly the same as at Cannes, as is also the relative humidity, 72·8 per cent, according to the observation of Andrews and Freeman.

While the climatic features in the main are identical, the less amount of wind at Mentone renders it a much more suitable place for those whose main object is not amusement but health; and in accordance with this view we find as a matter of fact that the large majority of the winter visitors to this resort are invalids, and amongst these, consumptives hold a first place. Valetudinarians, convalescents, and persons requiring simply a little rest, are also present in goodly numbers. Gouty and rheumatic patients are probably better off than in less sheltered stations. The tendency to neuralgic pain and to sleeplessness is less complained of at Mentone than elsewhere on the coast.

The diseases prevalent in the district are much the same as at the other Riviera stations, as already mentioned. In the autumn an intermittent fever, seemingly of true malarial type, is apt to affect the labouring population.

The hotels in Mentone are good, and less expensive than in the more fashionable Cannes.

## Bordighera

Bordighera is the first health resort on the Italian portion of the Riviera, being only 3½ miles from the French frontier. It is a small place, but it has been steadily growing in favour with winter visitors.

The peculiarity of Bordighera is its position on a promontory exposed to all the winds. In spite of this it does not suffer as much as might be expected.

The soil, unlike that of Nice and Mentone, is formed chiefly of sandstone.

Observations on the temperature have not yet been made for a sufficiently long time to afford trustworthy data. Hamilton states the mean winter temperature as about 52° F., and the number of rainy days is probably about the same as at Cannes or at Mentone.

The drinking water is good. Asthma, gout, and rheumatism are stated to be rare.

Bordighera is generally considered unsuitable for patients with fever or tendency to hæmorrhage, as well as for excitable and nervous cases, the climate being too "stimulating."

Phthisical patients of the lymphatic type get on well.

## San Remo

San Remo is the most important station on the Italian Riviera. It is a picturesque town of about 20,000 inhabitants, and has assumed the appearance of a fashionable resort, with good hotels and fine buildings, whereas forty years ago it had hardly emerged from the obscurity of a fishing village.

The rapidity with which it has grown in public favour is due not merely to the beauty of its surroundings, but to its sheltered position, being better protected from the north winds than any other station along the coast, with the exception of Mentone. The protection, however, is by no means complete. The mistral, or north-west wind, at times blows with a force unknown at Mentone. The protection also from the Greco, or north-east wind, is incomplete. The prevailing winds, however, are a cold and rough wind from the east and a warm, moist wind from the south-east (scirocco).

The winter temperature of San Remo is about the same as that of Mentone, or perhaps a trifle lower. Dr. Marcet calculates that for the six winter months, November to April, the mean temperature is 51·3° F. at San Remo, 51·5° F. at Mentone, and 50·8° F. at Cannes. The mean temperature of January, however, appears to be only 46·5° F. Owing to the greater windiness of San Remo the cold is much more felt there than is the case at Mentone. In the matter of rainy days San Remo has an advantage over all its rivals. The average number for the six winter months (November till April) has been placed by different observers at from 26 to 30 or more, as compared with 47 at Mentone and 46 to 58 at Cannes. The relative humidity is placed at 68 per cent. According to this estimate, San Remo would seem to have a drier atmosphere than Cannes or Mentone, but the difference in the estimates is probably due rather to divergent hours and methods of observation than to any great difference in the atmosphere at the various places. The impermeable dry soil of San Remo does not allow the water to percolate through as does the sandy soil of Mentone. Snow and mist occur very seldom, as is the case along the whole Riviera.

The water supply of San Remo has been excellent for many years back, but in 1887 a new and even better supply was provided. The same source also supplies Ospedaletti.

Thus the main drawbacks of San Remo are its clay soil and its easterly wind.

The cost of living is very much the same as at Mentone,

perhaps a little less. Society is said to be dull,—prayer-meetings, according to Dr. Sparks, being much more in vogue than lawn-tennis or dances.

Rheumatism is not infrequent amongst the natives, though many people affected with this ailment spend the winter with advantage in San Remo. Dr. Sparks,[2] however, says that during the whole time he was there he suffered more or less constantly from the complaint. Phthisis is not very frequent, and when it does occur is said to run a slow course.

In the neighbourhood of San Remo is a leper hospital with 50 beds. It receives patients from a considerable district around, including the neighbouring French territory. The number of patients, however, becomes steadily fewer.

As to the class of cases suitable for San Remo rather than for Mentone, the main point to bear in mind is that San Remo has what is generally understood as a more "bracing" climate, the greater prevalence of wind making it suitable for a robuster type of patient. The difference, however, between San Remo and the west bay of Mentone is perhaps less than the difference between the east and the west bay of the latter town.

### Ospedaletti

Ospedaletti is a small resort between Bordighera and San Remo. Owing to its comparative freedom from dust and wind, as well as to the beauty of its surroundings, it is steadily and rapidly gaining in favour. People who prefer the repose of a small village to the bustle of more showy towns will find Ospedaletti a pleasant place to stay at.

### Alassio

Alassio has of late years acquired some prominence as a competitor for winter visitors. It lies 38 miles from Ventimiglia and about 56 miles from Genoa, and occupies a central position in a bay five miles wide.

Though a healthy place, it is not well sheltered. The north wind, or Tramontana, Dr. Sparks says, is not felt

close under the hills, but the town, which lies near the shore, is only very slightly protected.

### PEGLI

Pegli, about $5\frac{1}{2}$ miles west of Genoa, is another of the very slightly developed health resorts of the Italian Riviera; and as it is a place of summer residence for the Italians, especially for the Genoese, winter visitors, who might greatly increase the cost of living in the village, are not much encouraged.

Pegli is generally liked by those who have visited it, and many people return from winter to winter. The shelter from the north-east is not good, and the climate in general appears to be cooler and moister than that of Mentone.

There are but few English amongst the winter visitors, who are chiefly German.

Dr. Maund, who practised in Pegli for a couple of winters, as quoted by Sparks, says that "the cases which it seems to suit most admirably are cases of asthma." Dr. Sparks points out that asthma is a word of such vague meaning that this statement does not help us much. Probably, he adds, the so-called "asthmatics" of Pegli are persons with emphysema and bronchitis.

### GENOA

Genoa is quite unfit for the invalid. Winds from the north and the north-east predominate; then come winds from the south-east and south-west. The northerly winds are dry and cold, the southerly warm and moist. The alternation of these winds, with the attendant changes in temperature and in moisture, is trying even to healthy persons.

### NERVI

Nervi, about seven or eight miles south-east of Genoa, is a sea-bathing resort for the Genoese in summer. In

winter the visitors are mostly German, with a sprinkling of English.

The winter climate is very little if at all cooler, but distinctly moister than the climate of the western Riviera. The daily range of temperature is extraordinarily small—from 5° to 6° F. The town is fairly well sheltered from north and north-west winds.

Some patients who find the western Riviera too exciting prefer Nervi, as being soothing and more conducive to sleep and rest. For patients with dry, irritable catarrah of the bronchial tubes and larynx, the moister air has a calming influence.

### Rapallo

Rapallo, about eleven miles farther down the coast, is beautifully situated. As in Nervi, the visitors are chiefly German. No very exact statements as to its metereology are forthcoming, but it appears to be cooler and moister than Nervi and to have more rainy days.

Sestri Levante, another charmingly situated spot about ten miles south-east of Rapallo, is not sufficiently well sheltered to be altogether satisfactory as a winter resort.

Spezia is much visited by the Italians during the bathing season, but has hardly any winter visitors. The climate is mild, but rather moist.

### Ajaccio

Ajaccio, in Corsica, is distinguished from the Riviera health resorts by its greater warmth and moister air. The mean temperature in January is variously given as 49·6° F. and 50·4° F.; and the mean relative humidity for the seven months from October to April is stated to be 75.

Ajaccio is almost free from dust, the great plague of the Riviera. The winds also are for the most part of moderate intensity.

Ajaccio is suitable for cases with dry, irritable bronchial or laryngeal catarrh. People who find the Riviera "too

exciting," commonly do well at Ajaccio. For young and vigorous subjects the climate usually proves relaxing.

### SICILY

Palermo,[3] the capital of Sicily, is a large city with a mean temperature of 51·8° F. in January. The relative humidity for the same month is 74. From 1866 to 1880 the average number of rainy days was 14 for December, 14 for January, 12 for February, 12 for March, and 8 for April. The oscillations in temperature are much more marked at Palermo than at Syracuse, towards the southern extremity of the east coast.

At Syracuse the mean temperature for January is 52° F.; the relative humidity 75. The rainy days in the years 1868 to 1879 were 9 for December, 7 for February, 9 for March, and 5 for April.

Sicily is so interesting, both for its natural beauty and for its historical associations, that it attracts many winter visitors. Its rather moist climate, however, is hardly suitable for real invalids. The hotel accommodation at Palermo and also at Taormina is excellent, but elsewhere in the island leaves much to be desired.

### CAPRI

Capri, one of the most beautiful spots in the world, is only three miles long and one mile broad. It lies about 20 miles south-east of Naples and about 3½ miles from the promontory of Sorrento. It has a good winter climate. The mean temperature in January for the eight years 1885 to 1892, according to Dr. V. Cuomo, was 48·2°. The mean number of rainy days for the six months from November to April was 62; the mean relative humidity for the same six months was 66·4. The prevailing winds in the winter months come from the north and from the east, alternating with wind from the south, from the west, and from the south-west.

Dr. V. Cuomo, in his excellent little book (*L'Isola di Capri*, Napoli, 1894), states that cases of torpid phthisis and cases of chronic bronchitis do well at Capri in winter. From the invalid's point of view Capri has some drawbacks. Communication with the mainland is uncertain in rough weather; there is no English doctor resident on the island, and sanitation is in a very backward state.

### Other Italian Towns

A few words may be said about some of the chief towns of Italy. All the chief towns are subject in winter to cold winds, and to much greater variations of temperature than are the resorts on the Riviera. The relative humidity also is higher. None of these towns can be recommended for sufferers from bronchial or pulmonary ailments.

### Rome

Rome, the capital of Italy, has a mean temperature of 44° F. in January. It is subject to great oscillations of temperature, with changes in relative humidity and in the direction of the wind. The mean relative humidity in January is 74. From November to April the average number of rainy days is from 9 to 11 in each month. The relative annual frequency of the winds from 1866 to 1880 was 344 for the north wind, 278 for the south, 158 for the west, and 105 for the south-west.

The climate of Rome is usually classed as sedative or relaxing; but, as pointed out elsewhere, these terms refer essentially to the reaction of the organism, and therefore vary from person to person. For quiescent tubercle in fairly robust patients Rome is not unsuitable.

### Naples

Naples has a temperature two or three degrees higher than that of Rome; its mean January temperature being 46·7° F.,

as compared with the 44° F. of Rome. The relative humidity, 73 in January, is nearly the same as at Rome; but the rainy days are more numerous by two or three a month, being 11 to 14 a month in the months from November to March. The south-west is the most frequent wind in Naples; next come the north-east, the west, and the north-west. The changes in temperature and in humidity that go with alternations in wind are trying to persons subject to bronchial or pulmonary catarrh or to rheumatism; but for ordinary healthy persons the climate in winter is by no means unpleasant.

### Florence

Florence has a much more trying climate than either Naples or Rome. Its January mean temperature is 41° F.; that is nearly 2° below the temperature, 42·9° F., of Regent's Park, London, for the same month. The relative humidity is 76 for January, and the rainy days during the winter are about ten in each month. What especially makes Florence trying is the frequency of the north-east wind blowing down from the neighbouring hills, which are sometimes covered with snow.

Florence cannot be regarded as a good place for invalids with catarrhal troubles, though it suits some persons with depressed nervous system.

### Milan

Milan, though an attractive city for the tourist, cannot be recommended to the invalid. It lies in an exposed position, open to every wind that blows, and is liable to great alternations of temperature.

### References

1. W. Marcet, *Southern and Swiss Health Resorts*, Lond. 1883, p. 136.
2. E. I. Sparks, *The Riviera*, Lond. 1879, p. 339.
3. The Italian meteorological figures are taken, except where otherwise stated, from *Climatologia: Valori dedotti dalle Pubblicazione del R. Ufficio Centrale di Meteorologia*. Ministero di Agricoltura, Industria e Commercio, Roma, 1881.

# CHAPTER XIX

## CLIMATE OF THE BRITISH ISLES

The British Isles have a warmer and more equable climate than could be expected from their latitude. The mean temperature of England for the year is some 20° higher than can be accounted for by the direct heat of the sun. This large excess of warmth is due to the Gulf Stream, the heat from which is carried landwards by the prevailing south-west winds. These winds carry with them moisture as well as heat. Much of the moisture is precipitated as the air passes over the high ground of the west, extending more or less from the south of England to the north of Scotland. Thus it happens that the whole extent of the west of England and of Scotland is warmer, and has a heavier rainfall than any other portions of the country.

The influence of the Gulf Stream is most striking in the winter months. In January the same temperature prevails along the whole of the west coast from the north of Scotland to the south of Wales, along the eastern portion of the south coast, over the west of France away from the coast, and over the north of Italy. The January isothermal line for the south of Ireland runs through Devonshire, Cornwall, along the west coast of France, touches the north of Spain, passes a little north of the Riviera, and through Florence to the east coast of Italy.

If mean temperature alone were taken into account, the climates of these various lands might seem in January to be practically identical. In fact, however, no climates could well be more dissimilar. The south of Ireland, Devonshire,

and Cornwall are heated by the warm, moisture-laden winds from the Gulf Stream, while southern France and northern Italy owe their warmth mainly to the direct heat of the sun. A somewhat greater amount of rain falls on the Riviera than the average for the United Kingdom, but on the Riviera the rain comes mostly in the form of heavy showers with a clear sky between times, while the rainfall of the British Isles tends rather to take the form of an intermittent drizzle. At Nice there are about six or seven days in each of the winter months on which rain falls, while in England the number of rainy days is usually more than twice as great. The amount of precipitation at Nice [1] for the six months from November to April inclusive is about 20 to 22 inches, while at Greenwich [2] the average for the same months from 1866 to 1890 was 11·31 inches.

The proportion of cloud also is greater in the United Kingdom, and the proportion of sunshine less than on the Riviera or other southern resorts. Almost cloudless days form rather more than one-half of all the days of each winter month on the Riviera, while the proportion in London is hardly 10 per cent. The amount of cloud-covered sky at English health-resorts during the winter varies from 65 to over 80 per cent. On the Riviera it is rather under 50 per cent, and in Cairo under 40 per cent.

The British Isles are thus distinguished climatologically from the Continent by their high degree of humidity and by the consequent absence of extremes of heat and cold. While these are the dominant features, there are wide differences in climate between different portions of the country. From the east coast of England to the west coast there is a well-marked increase of rainfall. If we look at a map showing the rainfall and one showing the elevation of the country, we are struck by the fact that the areas of heavy rainfall coincide pretty closely with the raised ground. The warm, moist winds sweeping over the high ground of the west, and becoming cool as they ascend, discharge much of their moisture on the windward mountain side. The rate of cooling is 1° F. for each 300 feet of elevation; and as

the hills and mountains are for the most part not very high, the winds still retain a good deal of moisture when descending on the leeward side of the range. The rainfall at many stations in the west of England and Scotland is about 50 inches, and in places reaches as much as 70 or 80 inches or more. The greatest precipitation is, as a rule, not along the coast, but at some distance inland where the ground begins to rise. Over the greater portion of England the rainfall is 30 inches; and over the south-east coast only about 24 to 25 inches. Moray Firth and Nairn in the north of Scotland share with the south-east coast the distinction of having the lowest rainfall in the United Kingdom. The temperature of various parts of the country shows considerable variations apart from the influence of altitude. The chief factors in determining the various degrees of warmth in different parts of the country are latitude and proximity to the Gulf Stream. Cornwall and Devonshire more than any other part of the country derive benefit from both of these sources. A southern aspect and the shelter of hills or of trees are powerful aids in raising the temperature of a place.

The east coast of England, though less rainy than the west coast, is more subject to fogs. Statistics on the subject are available only for four years. Mr. R. H. Scott[3] says: "From these returns it appears that in winter the very foggiest district is the east coast of England,—Yarmouth and North Shields recording respectively thirty-four and twenty-eight days in the space of four winters or twelve complete months. Next to these comes our much abused London, and equal to it is Oxford, both with twenty-four days. In their case it is the Thames valley which is to blame, while the east coast stations get their fogs from the sea. That this obscurity of the atmosphere is not peculiar to the two parts we have named is proved by the fact that Dover and Scarborough also enjoy an unenviable pre-eminence among British stations as regards winter fogs. In spring Shields and Scarborough again come out as foggy. . . .

"The Channel and the south coast of England are also rather foggy in winter, but the number of fogs at Plymouth or at Hurst Castle, at the entrance of the Solent, is thirteen, as compared with the thirty-four already quoted from the east coast."

In the west, Mr. Scott tells us, the wettest season is late autumn and winter, while in the east the greatest rainfall comes rather earlier in the year, "the winter months being drier, comparatively, owing to the greater prevalence of long continued cold and dry winds."

Once more I quote from Mr. Scott's valuable and interesting paper a table showing the prevalence of gales over the British Isles for the fifteen years from 1871 to 1885, and the percentages for the four quadrants, north-east, south-east, south-west, and north-west.

| | Total Number of Gales in Fifteen Years. | Percentages. | | | |
|---|---|---|---|---|---|
| | | N.E. | S.E. | S.W. | N.W. |
| England, S.W. | 328 | 6 | 15 | 48 | 32 |
| The Shetlands | 281 | 14 | 29 | 30 | 26 |
| Ireland, S.W. | 277 | 5 | 16 | 62 | 17 |
| Scotland, N.W. | 275 | 7 | 16 | 44 | 33 |
| The Irish Sea | 265 | 7 | 14 | 50 | 28 |
| Scotland, E. | 229 | 9 | 23 | 33 | 35 |
| Ireland, N. | 198 | 6 | 18 | 42 | 34 |
| England, S. | 190 | 8 | 5 | 54 | 33 |
| England, N.E. | 172 | 17 | 18 | 40 | 25 |
| England, E. | 160 | 15 | 11 | 57 | 32 |

Hence it appears that the south-west is the stormiest district in England. Storms are most prevalent during the winter months, and especially in January and November.

In physiological action, as in temperature, the climate of the British Isles lies midway between the warm and the cold climates. For the healthy, active race that occupies these islands probably no other type of climate on the face of the earth would be more suitable. The heat even in summer is seldom oppressive in comparison with the summer

heat of southern Europe; nor is the cold of winter so intense as to blunt or to paralyse the activity of the nervous system. The great heat of tropical countries and the severe cold of an arctic winter both alike are apt to have a depressing or enervating effect. The climate of the British Isles, while not without blemishes of its own, is at least free from these drawbacks. The cloud-covered skies, the frequent rains, and the high relative humidity of the atmosphere tend perhaps to produce a sober or gloomy state of mind as contrasted with the light-heartedness of southern nations. The mental reserve of the English and of the Scotch must not, however, be put down wholly to climate. Ireland has a climate not less humid than has England, but her inhabitants vie with the southern nations in lightness and brightness of spirits.

The health of the British Isles compares favourably with that of other European countries except Norway, Sweden, and Denmark.[4] The mortality of the United Kingdom for 1896 was 17·1, as compared with 18·4 for Switzerland, 20·2 for France, 20·8 for Germany, and 24·2 for Italy. This lower mortality in the United Kingdom can, however, hardly be ascribed entirely, or indeed chiefly, to climate. The main cause of the greater healthfulness of the British Isles is the greater attention paid to sanitary and hygienic arrangements. The death-rate in England and Wales from tubercular diseases has diminished enormously in several European countries, but especially in England. The mortality from phthisis in England in 1896 was 1307 per million living,—little more than half what it was forty years ago, and much less than in any continental country to-day.

Typhoid fever has diminished in like manner. In 1896 the mortality from this disease was 166 per million living; in France it was 230. In Germany the disease is more than twice as fatal (mortality 406 per million in 1881-87); in Austria more than four times as fatal (731 per million in 1881-84); and in Italy nearly six times as fatal (937 per million in 1881-84).

The number of deaths from pneumonia in 1896 in England, 1149, was nearly the same as in France, 1167 per million; but the number of deaths from bronchitis was considerably greater in England than in France, 1539, as compared with 1160. The figures for Germany and Italy are higher still, and for Switzerland lower than for England.

Rheumatic fever and rheumatism of the heart appear to have caused in proportion to population twice as many deaths in England as in Russia or in Italy, and more than four times as many as in Switzerland, the proportions being respectively about 115, 54, 50, and 26 per million. These figures, though not representing the same years, are roughly comparable, as the mortality from rheumatic ailments does not vary greatly from year to year.

How far the climate is to blame, and how far the soil, for the frequency of these complaints is still an unsettled point. Both elements are, no doubt, factors in the causation. In so far as a damp, ill-drained, or polluted soil serves as a culture ground for pathogenic organisms, we may hope to show a steadily diminishing mortality through the extension and more stringent application of hygienic measures.

To enumerate all the places in the United Kingdom that are worthy of mention as health resorts is obviously impossible, nor indeed is it at all necessary. A short account of the best-known stations will suffice. One caution has always to be borne in mind. The difference in climate of two portions of the same town may exceed the difference between places far distant from each other. Nearness to the coast or to woods, exposure to winds, or shelter by hills or trees, altitude,—these and other circumstances may outweigh many degrees of latitude or of longitude. When the principles on which these differences depend are understood there will be little difficulty in choosing correctly according to the requirements.

We shall consider in turn the south, the west, and the east coast stations, and then the inland resorts. For some of the most important places I give the chief meteorological details in tabular form:[5]—

1881-1890.

| | | Temperature. | | | Mean Relative Humidity at 9 A.M. | Mean Clouding, 9 A.M. | Mean Rainfall, 9 A.M. | No. of Rainy Days. |
|---|---|---|---|---|---|---|---|---|
| | | Mean Min. | Mean Max. | Mean Daily Range. | Per cent. | 0-10. | Inches. | |
| Margate . . . . | Jan. | 34·8 | 43·1 | 8·3 | 90 | 7·6 | 1·72 | 16 |
| | July | 54·0 | 68·5 | 14·5 | 74 | 6·8 | 2·12 | 14 |
| | Year | 43·7 | 54·6 | 10·9 | 82 | 6·9 | 23·31 | 169 |
| Ramsgate . . . . | Jan. | 34·4 | 43·5 | 9·1 | 90 | 7·5 | 1·62 | 15 |
| | July | 53·6 | 69·0 | 15·4 | 74 | 6·4 | 2·49 | 13 |
| | Year | 43·3 | 55·3 | 12·0 | 82 | 6·7 | 24·23 | 163 |
| Brighton . . . . | Jan. | 35·0 | 44·8 | 9·8 | 87 | ... | 2·67 | 16 |
| | July | 55·1 | 67·9 | 12·8 | 77 | ... | 2·60 | 12 |
| | Year | 44·2 | 55·7 | 11·5 | 80 | ... | 28·75 | 159 |
| Worthing . . . . | Jan. | 34·5 | 43·5 | 9·0 | 90 | 6·6 | 2·30 | 16 |
| | July | 54·2 | 67·0 | 12·8 | 78 | 6·1 | 2·32 | 12 |
| | Year | 43·5 | 55·1 | 11·6 | 83 | 5·9 | 26 54 | 157 |
| Ventnor . . . . | Jan. | 37·4 | 45·7 | 8·3 | 88 | 6·8 | 2·60 | 16 |
| | July | 55·3 | 67·0 | 11·7 | 79 | 6·1 | 2·41 | 14 |
| | Year | 45·5 | 56·1 | 10·6 | 81 | 6·1 | 28·13 | 164 |
| Bournemouth [1] . . . | Jan. | 34·4 | 44·7 | 10·3 | 85 | ... | 2·47 | 14·3 |
| | July | 54·2 | 71·0 | 16·8 | 69 | ... | 2·07 | 14·3 |
| | Year | 42·6 | 57·1 | 14·5 | 77·7 | ... | 27·6 | 158·3 |
| Weymouth . . . . | Jan. | 37·1 | 45·7 | 8·6 | 87 | 6·8 | 2·33 | 16 |
| | July | 54·6 | 66·8 | 12·2 | 77 | 4·7 | 1·92 | 13 |
| | Year | 44·9 | 55·2 | 10·3 | 80 | 5·4 | 27·01 | 157 |
| Sidmouth . . . . | Jan. | 36·2 | 45·5 | 9·3 | 91 | 8·1 | 2·86 | 18 |
| | July | 53·1 | 65·7 | 12·6 | 82 | 7·3 | 2·92 | 18 |
| | Year | 43·5 | 54·9 | 11·4 | 85 | 7·2 | 32·44 | 204 |
| Falmouth . . . . | Jan. | 39·8 | 47·3 | 7·5 | 88 | 7·9 | 4·09 | 21 |
| | July | 54·4 | 65·4 | 10·9 | 79 | 6·9 | 3·48 | 17 |
| | Year | 45·9 | 55 3 | 9·4 | 82 | 6·9 | 43·56 | 204 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Torquay | Jan.[2] | 42·5 | 50·7 | 8·2 | ... | ... | 4·37 | 24 |
| | ,, [3] | 36·4 | 45·1 | 8·7 | 87·6 | 7·5 | 2·82 | 15·8 |
| | July | 53·4 | 67·8 | 14·4 | 80·9 | 6·2 | 2·90 | 16·4 |
| | Year | 44·0 | 55·8 | 11·8 | 82·3 | 6·6 | 34·68 | 187·1 |
| Weston-super-Mare | Jan. | 36·1 | 44·9 | 8·8 | 90 | 8·0 | 2·23 | 17 |
| | July | 55·1 | 66·9 | 11·8 | 78 | 6·7 | 2·90 | 17 |
| | Year | 44·3 | 55·5 | 11·2 | 84 | 7·0 | 28·87 | 178 |
| Scarborough | Jan. | 34·5 | 42·2 | 7·7 | 91 | 7·0 | 2·02 | 16 |
| | July | 52·6 | 65·6 | 13·0 | 76 | 6·3 | 2·81 | 16 |
| | Year | 42·4 | 52·5 | 10·1 | 83 | 6·5 | 27·50 | 197 |
| Lowestoft | Jan. | 33·8 | 42·6 | 8·8 | 91 | 6·9 | 1·44 | 15 |
| | July | 52·5 | 67·4 | 14·9 | 75 | 6·6 | 2·74 | 15 |
| | Year | 42·2 | 53·9 | 11·7 | 83 | 6·8 | 24·16 | 173 |
| Buxton | Jan. | 30·0 | 40·1 | 10·1 | 92 | 7·9 | 4·66 | 17 |
| | July | 48·4 | 65·1 | 16·7 | 78 | 7·1 | 4·43 | 16 |
| | Year | 37·7 | 51·6 | 13·9 | 85 | 7·3 | 49·31 | 196 |
| Cheltenham | Jan. | 32·4 | 42·8 | 10·4 | 90 | 7·5 | 1·13 | 17 |
| | July | 51·2 | 69·2 | 18·0 | 77 | 6·8 | 2·82 | 18 |
| | Year | 40·3 | 55·3 | 15·0 | 83 | 7·0 | 27·50 | 190 |
| Regent's Park | Jan. | 33·8 | 42·9 | 9·1 | 89 | ... | 1·91 | 15 |
| | July | 53·8 | 71·0 | 17·2 | 73 | ... | 2·68 | 15 |
| | Year | 42·4 | 56·1 | 13·7 | 81 | ... | 25·17 | 165 |
| Southampton | Jan. | 32·6 | 43·9 | 11·3 | 92 | 7·3 | 2·67 | 18 |
| | July | 51·6 | 69·9 | 18·3 | 73 | 6·9 | 2·64 | 17 |
| | Year | 40·9 | 56·6 | 15·7 | 81 | 6·8 | 29·22 | 187 |
| Blackpool | Jan. | 33·5 | 42·5 | 9·0 | 90 | 7·5 | 2·96 | 19 |
| | July | 52·8 | 64·3 | 11·5 | 78 | 6·1 | 3·62 | 17 |
| | Year | 41·9 | 52·9 | 11·0 | 84 | 6 5 | 34·23 | 194 |
| Guernsey | Jan. | 39·7 | 47·0 | 7·3 | 89 | 7·3 | 2·99 | 17 |
| | July | 55·1 | 66·5 | 11·4 | 83 | 6·2 | 2·12 | 13 |
| | Year | 46·9 | 56·1 | 9·2 | 85 | 6·6 | 32·53 | 179 |

[1] *Climates and Baths of Great Britain*, vol. i. p. 180.

[2] Tripe, 1873-77, 1880-89.

[3] *Climates and Baths of Great Britain*, vol. i. p. 88.

The south coast of England has long been popular both as a summer and as a winter resort. The stations from Falmouth in the extreme west become in a general way cooler and drier as we move eastwards to Folkestone or Dover. Consequently they are considered more bracing in the same order. Margate and Ramsgate may be included in the south coast group, though not strictly belonging to it.

### MARGATE

Margate, in the Isle of Thanet, on the north coast of Kent, has a well-established reputation as one of the most bracing of the sea-side resorts of England. Looking northwards, it is fully exposed to north-easterly winds, carrying with them in the present instance any healthful properties that may be communicated by the sea. The high ground to the south affords protection from the prevailing south and south-west winds, and protection at the same time from some of the showers that these winds bear. Margate has a rainfall of only 23·31 inches (1881-1890), the lowest record for any meteorological station in the kingdom. The annual number of rainy days for the same period was 169, as compared with 150 at Bude, on the west coast of Cornwall, 157 at Weymouth, 163 at Ramsgate, 164 at Ventnor, 196 at Buxton and at Dublin, 204 at Sidmouth and at Falmouth.

Margate lies on a chalk soil, and since 1883 has been supplied with an excellent system of drainage, which is gradually replacing the old cesspool arrangement. Its water-supply is copious and good.

Margate is resorted to chiefly in the summer months, and by two classes of visitors: the cockney excursionist, and sufferers from scrofula and other chronic forms of tuberculosis. For scrofulous children and young adults the sea breezes of Margate stand in high repute. In many such cases sea-bathing is a powerful adjunct in the treatment.

Neurasthenia from overwork, and nervous affections due

to prostrating or depressing influences, are likely to benefit from the fresh sea breezes to which Margate is exposed. An irritable nervous system, however, and its consequent sleeplessness are often made worse. Neuralgia and muscular rheumatism are common in the neighbourhood. Gout, eczema, and renal disease are looked on as contra-indications.

### Broadstairs

Broadstairs, on the east coast of the Isle of Thanet, is three miles south-east of Margate, and two miles north of Ramsgate. It is a quiet place of about 7000 inhabitants. It has the bracing qualities for which the neighbouring health resorts are famous, while it is free from the cheap "tripper" element that abounds in them. It caters for a better class and for a fuller purse than its neighbours. During the summer months it is a favourite resort for delicate children and for convalescents.

### Ramsgate

Ramsgate, at the south-east corner of the promontory of the Isle of Thanet, has a southern aspect, and is protected from north winds. It has a somewhat warmer climate, a greater range of temperature, and slightly greater rainfall, but rather fewer rainy days than has Margate.

Water-supply and drainage are excellent.

Ramsgate appeals to the same class of invalids and of pleasure-seekers as Margate.

### Dover

Dover is a healthy, bracing place, suitable for dyspeptics and for persons whose nervous system is somewhat run down. It is not a resort for advanced consumption or for the chronic bronchitis of the middle-aged or old, but it answers well for early phthisis in robust subjects. Unlike Margate, Dover is said to be useful in cases of insomnia.

Dover, like Ramsgate, Broadstairs, and Margate, has a chalk soil.

### Folkestone

Folkestone, a few miles farther along the coast, on a green-sand soil, has much the same climate and character as Dover. It is suitable for the same class of invalids, but is more visited, both by health-seekers and by pleasure-seekers, than is Dover.

### St. Leonards and Hastings

St. Leonards and Hastings together form a town of about 66,000 inhabitants. St. Leonards, the more fashionable portion, lies to westward. The aspect of the town is almost due south. The soil is of sand. The water-supply is good, and the drainage is excellent.

St. Leonards and Hastings have considerable variety of climate in different parts. The high hills at the back of the town are colder and more exposed than the lower lying portions of the town. The annual rainfall is about 29 inches, and the number of rainy days 187. The sunshine record is high. The mean daily range of temperature is 11·8° F.

Visitors are well provided with music and other forms of entertainment and recreation.

Hastings and St. Leonards belong to the more bracing class of sea-side resorts. While specially suitable for summer residence, they answer in winter also for the robuster class of invalids, for whom a moderate amount of wind may be no drawback. Patients with chronic non-febrile phthisis, and persons run down from overwork, get on satisfactorily the whole year round. Chronic bronchitis does well, even in elderly persons. Patients suffering from renal or rheumatic ailments are better off in a more sheltered place.

### Eastbourne

Eastbourne has a deserved reputation as a sea-side resort for the summer months. In climate it very much resembles

St. Leonards and Hastings, having a high sunshine record, about the same rainfall, and being protected from north winds by the downs at the back of the town, while fully exposed to the winds from the south and from the east.

The water-supply and the sanitary arrangements are excellent.

Eastbourne, besides being a suitable summer resort for convalescents after acute illness, answers well for the robuster type of sufferer from tuberculosis, and for persons who are run down in health from worry and overwork. For renal and rheumatic cases it is too much exposed to cold winds, especially during the winter months.

### Brighton

Brighton, the largest of sea-side resorts, has a population of about 125,000 inhabitants. It is largely patronised by city men, who run up to business every day, refreshed by a few whiffs of bracing air. It has thus come to be regarded almost as a suburb of London, and is spoken of as "London by the Sea." Like other south coast stations, it is fairly well protected on the north side, but is exposed to the winds from other quarters.

Though lacking in shelter both from sun and from wind, Brighton is well adapted for many classes of invalid, especially for those who are not very seriously ill. Dr. Newsholme, the Medical Officer of Health, after describing the meteorology of the place, says:—"It is evident from the preceding data that Brighton possesses a dry and bracing air, suitable for all debilitated persons. It is a well-known and favourite residence for retired Anglo-Indians. It answers well in all cases of anæmia and scrofulous diseases, and in rheumatic and bronchitic affections. While almost as bracing as places on the east coast, it has a warmer winter and as cool a summer, and the spring months are not quite so trying to delicate persons."

The death-rate is low for the population of the town. In spite of the fact that Brighton is the chosen place of

residence of a large number of invalids, its mortality usually occupies a favourable place in the list of the great towns, among which it is included.

Brighton is well provided with amusement and recreations for the healthy and for invalids.

### Worthing

Worthing, though only twelve miles west of Brighton, is often pointed to as an example of the great difference between health resorts close to each other. The meteorological figures, however, for the two places are almost identical, except that Worthing has a slightly greater relative humidity. Brighton, however, is usually held to be keen and bracing, Worthing to be soft and mild. Brighton has been likened to Scarborough, and Worthing to Torquay.

Worthing is useful in chronic bronchitis. It is recommended also for rheumatic and renal diseases.

### Isle of Wight

With the exception of Ventnor, the resorts of the Isle of Wight are chiefly frequented by pleasure-seekers, by the overworked, or by the convalescent. Shanklin and Sandown on the east coast are refreshing, breezy places during the hot months. Cowes is the recognised headquarters of the yachting world.

The Isle of Wight has a well-marked marine climate, characterised by moderate humidity, a comparatively low range of temperature, and cool sea breezes. Great differences are found, however, in the different parts of the island, according to the amount of exposure to sun and of shelter from wind.

Ventnor is the only winter resort in the Isle of Wight chiefly visited by cases of tuberculosis. The town, which has a population of about 6000 inhabitants, lies between the shore and the cliffs behind, houses occupying the

declivity to a height of 500 feet or more. Hence there is considerable variety in climate between the sheltered Undercliff and the exposed downs. The Undercliff, though freely exposed to wind from the south and east, enjoys remarkable protection on the north.

The average temperature of Ventnor during the summer months is between two and three degrees lower than that of London, while the average temperature during the winter months is between three and four degrees higher. In January the daily range of temperature in Ventnor is 8·3 degrees Fahrenheit; in Regent's Park 9·1. In July the average is 11·7 and 17·2 degrees for Ventnor and Regent's Park respectively. Ventnor has a yearly rainfall of a little more than 28 inches; Regent's Park a little more than 25 inches. The number of rainy days is practically the same in both places: 164 days in Ventnor and 165 in Regent's Park. The relative humidity for the year at 9 A.M. is 81 in both cases; and for January, 88 in Ventnor, and 89 in Regent's Park.

The drainage of Ventnor is good, the water pure, but hard.

Ventnor is suitable for moderately robust cases of chronic tuberculosis, whether of the lungs or of other organs, but is not to be recommended for severe hæmorrhagic cases or for advanced laryngeal disease. Scrofulous children do remarkably well.

The arrangement of the town on a declivity affords plenty of exercise which cannot well be avoided. This is to be borne in mind in regard both to cardiac and to pulmonary ailments.

Neuralgia and muscular rheumatism are common. Eczematous affections also do badly.

### Bournemouth

Bournemouth, situated on both sides of the small stream from which it takes its name, faces almost due south. It occupies the recess of a large bay, and is well

sheltered from cold winds by distant hills and wooded country. The Isle of Wight breaks the force of wind from the east. The Purbeck Hills serve the same office on the west, and the New Forest on the north-east.

The portions of the town known as the East Cliff and the Valley have the greatest amount of shelter. Sometimes, in fact, the absence of wind causes a feeling of stuffiness or oppression. The West Cliff, in which direction the town is extending, is somewhat more exposed.

Bournemouth has a much lower relative humidity than might have been expected. In January the percentage of moisture in the air at 9 A.M. is 85 as compared with 88 for Ventnor, 89 for Regent's Park, 90 for Margate, and 92 for Southampton and Buxton. The number of rainy days at Bournemouth, 158, compares favourably with the number, 165, noted at Regent's Park. The rainfall at Bournemouth is 27·6 inches, which is rather more than at Regent's Park, where the amount is 25·17 inches. The daily range of temperature in Bournemouth is comparatively high, as might be anticipated from the relative dryness of the air and the freedom from wind. In January the daily range is 10·3° F. as compared with 8·3° F. at Ventnor, and 9·1° F. in Regent's Park; in July the range is 16·8° F. as compared with 11·7° F. at Ventnor, and 17·2° F. in Regent's Park.

Bournemouth has a porous gravel soil, on a sandy subsoil, below which there is chalk.

The drainage and the water-supply are all that can be desired.

Bournemouth is visited chiefly by sufferers from diseases of the respiratory organs, especially tuberculosis. Cases in which the disease is not very active yield the best results here as elsewhere. The comparative freedom from strong wind is a point in favour of laryngeal cases.

Bournemouth answers well for cases requiring a mild climate—cases that could not stand the severe cold or the rarefied air of the Alpine resorts. Many persons, also, who have to a large extent regained their health on the Riviera or in the mountains find Bournemouth a pleasant place to

live in, without the drawbacks of exile in a foreign land. Valetudinarians and convalescents of all kinds, elderly people with chronic bronchitis, patients with the milder forms of Bright's disease, persons run down from over-work, are all likely to derive benefit from residence at Bournemouth.

### Weymouth

Weymouth, on the south coast of Dorsetshire, faces the east. Away from the sea fairly good protection from wind can be obtained.

Weymouth can boast the smallest average amount of cloud recorded at 9 A.M. at any meteorological station in the kingdom for the years 1881-1890, the proportion of the sky covered being in tenths, 5·4 for the year. Worthing, which has the next best record, shows 5·9 for the same time. The corresponding figures for Margate are 6·9, for Weston-super-Mare and Cheltenham 7·0, for Sidmouth 7·2, and for Buxton 7·3. The number of rainy days is low—157 for the year.

Weymouth is an excellent summer resort with good and safe bathing. It is suitable for scrofulous cases. Bronchial affections are rather common.

### Torquay

Torquay, situated in a recess on the northern shore of Torbay, has a southern aspect, and is well protected from winds from every quarter except the south, and to some extent the west.

Torquay is generally regarded as being rather "muggy" and relaxing. From an examination of meteorological tables alone this fact could hardly be discovered. The daily range of temperature is a trifle greater than at Margate or Scarborough, as will be seen by a glance at the comparative meteorological tables. The annual rainfall is 34·68 inches at Torquay in comparison with 27·5 inches at Scarborough, and only 23·31 inches at Margate. In Torquay there are

187·1 rainy days a year, in Scarborough 197, and at Margate 169. The relative humidity is rather less at Torquay in January, and rather greater in July than at Scarborough or Margate. The amount of clouding is much the same at all three places. In January the mean temperature in Torquay is 40·8° F.—that is, about two and a half degrees higher than in Scarborough or Regent's Park, and two degrees higher than in Margate; while in July the mean temperature in Torquay is less than half a degree higher than in Scarborough, and nearly three degrees lower than in Regent's Park, and two degrees lower than in Margate. The daily range of temperature in Torquay is 8·7° F. in January, and 14·4° F. in July—that is, nearly the same as in Margate, and rather greater than in Scarborough.

Scarborough and Margate are notably bracing places, and the contrast between their physiological action and that of Torquay is not a little striking when the close resemblance of several of the climatic factors is borne in mind. The essential difference in physiological action is no doubt due to the fact that Torquay has less wind than the other places.

Torquay is suitable for cases of dry, irritable catarrh of the upper air passages and bronchial tubes. Chronic phthisis appears to be rare in Devonshire, while the pneumonic or acute form is not uncommon. Acute rheumatism is not frequent in Torquay, though more prevalent throughout Devonshire as a whole than in England generally. Torquay is usually considered a proper place of residence for the chronic forms of Bright's disease, though renal disease occurs with average frequency throughout Devonshire. The mildness of the climate renders Torquay suitable for old people.

### Cornwall

Cornwall forms the south-west corner of England, and has a comparatively warm and equable climate at the

expense of a humid atmosphere. The warmth is mainly due to the Gulf Stream; the humidity to the position of the land, jutting out into the ocean. The north-western portion of the coast is fully exposed to storms sweeping across the Atlantic, but the south-eastern portion is comparatively well protected by a bold range of hills running to the north-east from the southern extremity of the county.

### Falmouth

Falmouth has always enjoyed a certain reputation as a health resort. It occupies a very sheltered position. In January the temperature is about five or six degrees higher than in Regent's Park, and two degrees higher than at Ventnor. In July, on the contrary, Falmouth is more than two degrees cooler than Regent's Park, and more than one degree cooler than Ventnor. The mean daily range of temperature is 7·5° F. for Falmouth in January, 8·3° F. for Ventnor, and 9·1° F. for Regent's Park; while in July the range is 10·9° F. in Falmouth, 11·7° F. for Ventnor, and 17·2° F. for Regent's Park. The relative humidity for January is practically the same, 88 to 89 in all three places; but in July Regent's Park has a relative humidity of only 73 as against 79 in Ventnor and in Falmouth. In the amount of rainfall and in the number of rainy days Falmouth far surpasses the other two places. The annual rainfall is 43·5 inches, and the number of rainy days is 204 at Falmouth, 28·13 inches and 164 days at Ventnor, and 25·17 inches and 165 days in Regent's Park.

Meteorological tables do not, however, as before remarked, fully indicate the differences as felt; and Falmouth belongs to the relaxing or "muggy" type of resort.

Falmouth is suitable for cases with dry, irritable catarrh of the pharynx, larynx, or bronchial tubes, and for some chronic cases of phthisis, but is not to be selected for cases of active tuberculosis.

Rheumatic affections are common throughout Cornwall, which should, therefore, be avoided by sufferers from these

ailments. Renal diseases, on the other hand, and calculous disorders of the urinary passages are rare. In such cases Falmouth offers many advantages compared with other parts of the country, though it is hardly as beneficial as somewhat drier and warmer regions, such as the Canary Islands.

Penzance has much the same climate as Falmouth, and is suitable for the same class of cases.

### Weston-super-Mare

Weston-super-Mare on the British Channel is well protected on the north and west by wood and hill, but is rather exposed towards the west, receiving in spring and autumn its full share of westerly gales.

Weston has a dry, absorbent soil, is well drained, and has an abundant supply of very hard, but otherwise pure water.

The meteorological statistics of Weston closely resemble those of Ventnor. Weston is, however, a trifle cooler, both in summer and in winter, has somewhat more cloud and humidity, and almost the same rainfall, but more rainy days —178 instead of 164.

Renal and urinary diseases are rare. Rheumatism and neuralgia are very prevalent, as are also bronchitis and catarrhal affections. Weston is suitable for persons who are run down from overwork. During the late autumn and early winter it answers well for early phthisis with dry or irritable cough.

### Blackpool

Blackpool on the Lancashire coast is a popular seaside resort, chiefly visited by "trippers" from the neighbouring towns in search of amusement rather than by invalids in search of health. It is, however, a bracing, healthful place, strongly resembling Scarborough in its meteorological elements, but exposed to the west instead of to the east

winds, and having a somewhat greater rainfall (34·23 inches as compared with Scarborough's 27·50). The number of rainy days is nearly the same in both places—194 at Blackpool, and 197 at Scarborough. Like Scarborough, too, it has a comparatively low daily range of temperature.

During the summer months Blackpool is an appropriate resort for persons who seek mental diversion, provided that the "tripper" element be not objectionable. The bustle and excitement of the place render it hardly fit for cases of phthisis, though climatically not unsuitable during the warm months for sluggish cases in persons of robust type.

### Southport

Southport has much the same kind of climate as Blackpool, but is quieter, and does not cater for the "tripper" element. It has, moreover, some reputation as a winter residence for persons affected with stationary phthisis.

### The Channel Islands

The Channel Islands have a warm, moist, equable climate with salt-laden breezes from the sea.

St. Helier, on the south coast of Jersey, is comparatively sheltered from north winds, whilst St. Peter's Port occupies an exposed situation on the side of a hill on the east coast of Guernsey. The meteorological reports from Guernsey resemble closely those from Falmouth, but show a somewhat higher relative humidity, though less clouding (at 9 A.M.), a smaller rainfall, and fewer rainy days. Jersey holds by a long way the highest record for sunshine in the British Isles.

Jersey is an admirable recruiting ground for the jaded or overworked professional or business man, quieting the irritable nerves and helping to overcome sleeplessness. The Channel Islands are rather too windy for most persons suffering from respiratory ailments. The early summer

and late autumn are the pleasantest seasons. Rheumatic ailments are prevalent throughout the islands.

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2. *Rainfall Tables for the British Isles*, 1866-1890, 1897, Official No. 114, p. 25.
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4. The health and death statistics are collected chiefly from the following: Davidson's *Geographical Pathology*, Edinburgh and London, 1892; various Reports of the Registrar-General of Births, Deaths, and Marriages in England, especially the Fifty-Ninth Report (1897), and the Supplement to the Fifty-Fifth Report (1895); the Forty-Second Report of the Registrar-General of Births, Deaths, and Marriages in Scotland (1898); the Thirty-Fourth Report of the Registrar-General of Ireland (1898); Statistique Sanitaire des Villes de France et d'Algerie, 1898; Preussische Statistik, 157, Die Sterblichkeit, 1899.
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# CHAPTER XX

## THE UNITED STATES

In the United States of America health resorts abound. Owing to the gigantic size of the country, to the great variety of its surface, to the presence of mountains and of large inland seas, as well as to the influence of the Atlantic and Pacific oceans, every type of climate is to be met with. The best way to deal with such an immense mass of material will be to select types of the various kinds of climate for full consideration, and to indicate in a general way the chief characteristics of other portions of the country that offer advantages from a health point of view.

Amongst the best known health resorts of the States are the high altitudes of Colorado; the greater part of Southern California; many places in Florida—Jacksonville, St. Augustine, and Tampa, for example; the Adirondack Mountains; Asheville in North Carolina, and a few other stations.

### Colorado

The State of Colorado occupies an extensive plateau in the centre of North America, and is traversed by the Rocky Mountains in a direction running roughly from north to south. The climatic features of the country are mainly determined by these facts. Owing to the elevation of the plateau—roughly from 4000 to 6000 feet—the main characteristics of mountain climates are observed—low barometric pressure, small absolute humidity, high solar radiation, and brusque changes of temperature. The mountain chain, running from north to south, has a considerable influence in addition. It causes the precipitation

of moisture that is carried so far in winds coming from the Pacific Ocean. As a consequence the atmosphere in the portion of the State that lies east of the Rocky Mountains has a very much lower degree of humidity—both relative and absolute—than would be accounted for by altitude alone. To some extent also this region is less swept by winds than would be the case without this natural barrier. Only on one side, however—the west—does this barrier exist, and from all the other points of the compass the chief health resorts of Colorado are exposed without let or hindrance to the violent winds that so often blow throughout the country.

The health resorts of Colorado are legion; but only two or three have attained more than a local reputation. Of these Denver—the most important city of the State—is the oldest and best known. Colorado Springs is a smaller place, and has to a greater extent the character of a health resort. Glenwood Springs has a considerable local reputation as a summer resort for rheumatic invalids. Besides these there are many small places at present consisting of hardly more than a hotel, from 1000 to 2000 feet above the level of Denver and Colorado Springs, where people go to get away from the great heat of summer. Estes Park and Palmer Lake, both over 7000 feet above sea-level, are favourite summer quarters.

### Denver

Denver has an altitude of 5196 feet, and stands in an open plain, which might almost be called a desert. About 15 miles to the west are the foot-hills, and about 30 miles in the same direction the main ridge of the Rocky Mountains. Apart from the Rocky Mountains the country is perfectly flat and quite devoid of trees.

Denver itself is a large and busy town. It is very beautifully laid out, has fine buildings, broad streets, a large number of which are planted with trees which by a system of irrigation are kept in good condition. The water-supply and general arrangements of the town are on the whole fairly satisfactory. Electric tramcars, magnificent

shops, and tasteful residences give the impression of a prosperous and attractive city.

The growth of Denver is almost, if not altogether, without parallel. In 1870 the population was 4759; in 1900 it had reached 138,859. With this rapid growth many of the characteristics that in earlier days rendered it a suitable health resort for consumptives have now disappeared.

The main features of the climate are set out in the table on p. 260.[1]

One of the most striking peculiarities of the climate of Denver—and in fact of any mountain climate—is the occurrence of a great number of exceptional days. Variations in temperature, in humidity, and in the amount of wind, are apt to take place much more suddenly than in low altitudes generally.

The chief characteristics of Denver are a large amount of sunshine, very little rain, a hot summer, and a cold winter. The mean temperature of July is 72° F.; but the temperature in the summer months occasionally runs up to 95° or 100° F.,—the nights, however, being usually fairly cool. The mean temperature in January is 27·2° F., but during the months from November to March temperatures from 10° to 25° below zero Fahrenheit may be recorded. The air as a rule is very dry, and snow rarely falls in winter, and then does not remain on the ground for any length of time. The amount of wind is the most serious drawback to the climate. Very rarely, indeed, is there absolute calm, and not infrequently there are wind storms of great violence. When the wind blows hard, clouds of fine dust are carried into the air, compelling the invalid to keep indoors. The average velocity of the wind at Denver is 6·3 miles an hour, as compared with 9·2 miles an hour at New York, and about 9 miles at Colorado Springs. Dr. Huntington Richards says, "So far as we can judge from the various data now presented, the climate of New York is seemingly characterised by a more frequent occurrence of calms, by a less frequent occurrence of winds of exceptional velocity, and by a greater average velocity of wind than is the climate of Denver."

DENVER—12 Years, 1872 to 1883. Hours of Observation: 7 A.M., 3 P.M., 11 P.M.

| | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature | 27·2 | 32·1 | 39·8 | 46·2 | 56·6 | 66·8 | 72·0 | 70·5 | 60·7 | 49·9 | 37·1 | 30·5 | 49·1° F. |
| Mean daily range | 24·7 | 23·3 | 25·4 | 25·0 | 25·5 | 26·6 | 26·8 | 26·0 | 28·0 | 26·1 | 24·3 | 23·0 | 25·2° F. |
| Range of temperature for the period | 96·0 | 94·0 | 91·0 | 79·0 | 65·0 | 62·0 | 60·3 | 61·0 | 65·0 | 85·0 | 94·0 | 96·0 | 134·0° F. |
| Mean relative humidity | 53·3 | 53·2 | 48·2 | 48·5 | 48·5 | 43·2 | 46·6 | 46·9 | 44·0 | 44·7 | 50·3 | 55·5 | 48% |
| Average rainfall in inches | 0·69 | 0·43 | 0·86 | 1·71 | 3·05 | 1·60 | 1·89 | 1·54 | 0·96 | 0·79 | 0·72 | 0·71 | 14·95 |
| Average number of fair and clear days | 27·2 | 24·7 | 24·4 | 22·6 | 23·8 | 26·4 | 26·8 | 26·0 | 25·8 | 26·0 | 25·4 | 28·2 | 307·3 |
| Average velocity of wind in miles per hour | 6·3 | 6·1 | 7·3 | 7·3 | 6·8 | 6·3 | 6·1 | 5·6 | 5·5 | 6·0 | 6·0 | 5·9 | 6·3 |

For what cases is Denver suitable? Its character as a town makes it unfit for the great mass of consumptives. Those, however, whose disease is arrested, who have a fairly robust constitution, and whose calling in life can be exercised only in a large town, may be able to live in Colorado in comparative health and at the same time to earn their livelihood—an advantage presented by very few places.

In regard to the means of gaining a livelihood in Denver a word or two may be said. The labour market is overstocked in every direction by men who are willing to take almost any remuneration with which, in addition to their own private resources, they may be able to eke out an existence. Manual work of a rough kind is indeed to be had, but very rarely anything that would suit an invalid. If, however, a man has friends in the place he may be able either to get a situation or an opening in business. A small amount of capital—if care is taken not to lose it—will soon multiply and increase.

Asthmatics do well in Denver; and I met there several people in good health, who, after striving in vain against their ailment elsewhere, had settled down in Denver and lived comfortably.

Of persons whom I sent out to Denver and its neighbourhood, the subsequent history of fifteen is known to me, and several of these I had an opportunity of examining after they had been resident in the country from one to three or four years. They had all previously spent one or more seasons in Davos, and when they went to Colorado their disease was either inactive or nearly so. Three of these cases I found had improved, six were in much the same condition, four were worse, and two had died. Of the three cases in which improvement took place two had done decidedly better than they had done in Davos. In all the other cases the result was hardly as good as might reasonably have been expected in Davos, though in some instances before they reached their destination a considerable aggravation of the disease had occurred, which to some extent diminishes the value of comparison.

These patients had for the greater part spent their winter in Denver, and the summer at one of the higher stations,—such as Estes Park,—or in camping out in the mountains at an altitude of from 7000 to 10,000 feet above sea-level, the intermediate elevations seemingly giving the best results. One patient, whose progress had been exceptionally good, had been chiefly in Colorado Springs, where he had settled down in business.

Most of the patients thought themselves that they had made more progress in Davos, though a couple of them were very strong in the expression of the opposite opinion. Almost without exception they complained of having had a severe bronchial catarrh very shortly after their arrival in Denver, and this had in some instances proved a serious drawback to their subsequent progress. This catarrh, it would seem, very frequently attacks new-comers; and according to the majority of my informants there is great liability to bronchial catarrh at any time.

Another complaint frequently mentioned was dryness of the nose and throat, a trouble common in all exceptionally dry climates.

Two or three drawbacks, in addition to the wind and dust, were strongly emphasised by my old patients. Chief among these was the great facility there is for young men to yield to the temptations of a large city. Restraints customary in England are unknown there. One has no reputation to lose, or rather a reputation is not lost quite so easily as at home. In fact, each person is expected to look after himself and his own interests, and not to worry about his neighbour's doings. What renders the danger from this source more pronounced is the difficulty of getting into really nice society unless one is furnished with good introductions. For steady young men able to take care of themselves Denver and the neighbouring resorts offer many advantages; but in very few instances will an invalid, especially if a woman, have the same opportunities of pleasant society without risk to health as in the European resorts.

### Colorado Springs

Colorado Springs is, after Denver, the next most important town in the State as a health resort. It lies at an altitude of 5992 feet above the sea-level, and about 73 miles south of Denver, 10 miles east of the summit of Pike's Peak, and about 6 miles from the base of the mountain—which is 8000 feet above the level of the surrounding plateau, or more than 14,000 feet above sea-level. The general characteristics of the surrounding country are much the same as in the case of Denver. But Colorado Springs, being nearer to the hills, has the advantage of finer scenery in its immediate neighbourhood. The town cannot boast of many fine buildings, and does not present a very imposing appearance. It was founded in 1871, and the population in 1900 was 21,085. Its chief industry, in addition to catering for consumptive invalids, is connected with mining.

The advantages claimed for Colorado Springs as a health resort are a large proportion of sunshine, a dry atmosphere, pure air, and—owing to its position close to the Rocky Mountains—shelter from wind, with only a small amount of evening shadow. The claim that it is well sheltered by the mountains conveys only a small part of the truth. It is open to winds from every point of the compass except the west, the wind blowing chiefly from the south-east during the warm part of the day, and from the north-west during the night and early morning; that is, to some extent from the mountains during the night and from the plains during the day. In fact, the most serious drawback to Colorado Springs is its excessive windiness. It is much more windy than Denver, where the mean velocity of the wind is 6·3 miles an hour, while at Colorado Springs it is about the same as in New York, and violent storms occur with greater frequency. These facts are shown in a table compiled from tables by Dr. Huntington Richards [2] in the *Reference Handbook of the Medical Sciences*. It should be mentioned that the mean temperature for January is stated by Dr. Solly [3] to be 26° F.

The evil effect of the wind is greatly aggravated for

COLORADO SPRINGS—Hours of Observation: 7 A.M., 2 P.M., 9 P.M.

| | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature for 1884 . | 28·10 | 26·18 | 36·37 | 41·26 | 52·09 | 63·30 | 70·64 | 65·11 | 61·65 | 50·69 | 36·40 | 24·07 | 46·32° F. |
| Mean daily range, 1884 . | 27·62 | 26·57 | 23·76 | 22·82 | 23·00 | 19·52 | 27·25 | 23·55 | 27·57 | 28·43 | 29·78 | 29·30 | Deg. Fahr. |
| Monthly range of temperature, 1884 | 65·0 | 83·5 | 54·0 | 52·0 | 56·0 | 41·0 | 39·0 | 38·0 | 50·5 | 68·5 | 49·5 | 81·0 | 113·0°F. |
| Mean relative humidity, 1884 | ... | ... | ... | 57·5 | 61·0 | 56·8 | 54·5 | 57·4 | 45·9 | 53·0 | 54·0 | ... | Per cent |

Fair and clear days, 5 to 7 years, 316 days in the year.

Average velocity of wind, 9 miles an hour.

invalids by the character of the dust, which is alkaline and very irritating. The number of days on which on account of wind and dust storms one is unable to go out is considerable. During these dust storms the sun may be shining beautifully and the temperature of the air may be pleasant. The wind and the dust were the main subjects of complaint by those who, in spite of all drawbacks, liked the climate and found that the place agreed with their health.

The town is provided with a satisfactory system of drainage, in which the sewage is received into pits, where the solid matter is deposited, the liquid portion percolating away. Excellent water is brought by iron pipes from a distance of about six miles. The soil below the alkaline surface of two feet consists mostly of sand and gravel.

I quote from Dr. Huntington Richards, in the *Reference Handbook of the Medical Sciences*, the account given by Dr. Ely, who records his personal experience:—

"Visitors to Colorado Springs may fairly expect to find a remarkably dry atmosphere, a rainless winter, a large amount of clear weather, a very warm sunshine, and the purest of air. . . . They must not expect to realise all that is described by enthusiasts. . . . They will find that the amount of time which they can spend out of doors will depend somewhat upon their ability to take active exercise and to resist cold, and they will encounter severe storms and a goodly number of 'exceptional' days, when they will revile the wind, the dust, the great changes of temperature, the low-hanging clouds, and will avow that the weather is no better than at home. They will find a winter climate by no means so seductive as that of more southern latitudes, but they will experience some of the finest winter days imaginable, and a sunshine so warm that I have been able to sit out comfortably when the mercury was only 2° above zero. Moreover, they can stay here, if it suits them, the year round without the necessity of fleeing before a spring thaw or a dangerous summer heat. . . . Nor is the snow always licked up by the dry air in the mysterious way so often pictured to us. It does disappear very rapidly as a

rule, but a visitor must not be surprised if he occasionally encounters mud and slush, and sees the snow going the way of all eastern snow . . . that it is never muddy here for more than a few hours is not strictly true. I have seen here genuine fogs, very dense, and lasting sometimes all day. But fogs are uncommon and scarcely worth mentioning, were not their existence so often denied. Then, too, there are the winds, which are surely both disagreeable and objectionable. . . . Many a clear, sunshiny day is so spoiled by cold wind as to be lost to the invalid, and the winter days, when there is not more wind than is agreeable, are decidedly in the minority. It is difficult to believe that a climate like this, minus the winds, would not be a better one. . . . Dr. Fisk's tables give an average of only twelve calm days in the whole year in Denver. His tables also show that the prevalent wind here is from the south, and he lays stress upon 'a prevailing balmy and salubrious south wind' as one of the advantages. . . . The fact is, I believe, that the south wind here is one of the most chilly and disagreeable of all, and that if any wind deserves the name of balmy it is that which comes from the west."

Colorado Springs and the health resorts generally of Colorado are suitable only for patients with a considerable reserve of vitality. Patients at a low ebb of life, with poor circulation and feeble assimilative powers, do better in the lowlands and in a warmer and less dry climate.

## California

Southern California—that is the portion of the State lying south of San Francisco—has for many years attracted attention, not merely on account of its great natural resources, but for its beautiful climate. The climate is in many respects unique, and is due to the southern position of the country, with the Pacific Ocean on one side and a range of mountains succeeded by a high plateau on the other. The distance from San Francisco to the most southern city—San Diego —is about 500 miles. The State varies in breadth from 100 to 200 miles. Two or three mountain chains run lengthwise more or less

parallel with the coast-line, that is, in a south-easterly direction. Below Point Conception—a little more than half the distance from San Francisco to San Diego—the coast takes a more easterly bend and has, consequently, a more southern aspect.

A great number of different climates are found throughout the portion of country just described, but they all have certain features in common—mild winters, cool summers, and abundance of sunshine. The differences in climate depend upon the latitude, the nearness to the coast or distance from it, the elevation and position in regard to protecting mountains. Below Point Conception the climate is distinctly milder than in places farther north.

### San Francisco

San Francisco, the capital city of California, though not in any sense a health resort, requires a few words, inasmuch as it exhibits in a marked degree some of the peculiarities of the entire coast. The mean temperature in San Francisco for the year is 55·6° F., in winter 61·2° F., and in summer 58·4° F.; in January 50·3°, in April 54·3°, in July 58·1°, in October 59·3° F. The lowest mean daily range of temperature, 8·6° F., is in January; the highest, 12·5° F., is in September. During the winter months the wind blows with moderate force—7 miles an hour; but during the summer months its violence becomes excessive—between 12 and 13 miles an hour; and the hotter the season the stronger the wind. This peculiarity is due to the fact that San Francisco practically lies in a funnel leading towards an inland desert where the surface becomes overheated by the rays of a powerful sun, and the cold air from the ocean rushes in to supply the vacuum thus caused in the interior of the country. As a further consequence of the inrush of moist air from the ocean great variations in humidity and in sunshine are apt to occur, as Blodget,[4] quoting Dr. Gibbons of San Francisco, says, "There is no conceivable admixture of wind, dust, cloud, fog, and sunshine, that is not constantly on hand during the summer at San Francisco." To a less extent are these qualities found in winter, but at no season of the year are they entirely absent.

## San Diego

Amongst the places really suitable for invalids the most popular are San Diego, with its near neighbour Coronado Beach, Santa Barbara, and Monterey, all on the coast; Passadena in the immediate neighbourhood of Los Angelos, and about 25 miles off the coast, and Riverside, somewhat farther inland. In addition to these places there are others innumerable, where certain invalids could pass the whole year round in comfort.

San Diego lies in the extreme south-west corner of the State on the north-east shore of the bay of its own name. Coronado Beach, on a thin neck of land forming the extremity of the opposite shore, is about ten or fifteen minutes' distance by ferry-boat, or a couple of hours by land. San Diego is pleasantly situated on the slope of a hill, and is a thriving, well-built city, with broad streets, a good water-supply, and generally satisfactory sanitary arrangements.

San Diego has the mildest climate and most equable temperature to be found in the whole State. Its winter, with a mean temperature of 54° F., resembles roughly spring and autumn in England. San Diego is also comparatively free from wind. As a counterbalancing drawback it has a higher degree of humidity than any of its rivals, and is usually visited in winter by a morning fog which, however, as a rule, clears off between nine and ten o'clock. For the

| | Nov. | Dec. | Jan. | Feb. | March. | April. |
|---|---|---|---|---|---|---|
| *Mean Temperature* | | | | | | |
| San Diego (1871-83) . | 58·2 | 55·6 | 53·6 | 54·3 | 55·6 | 57·7 |
| Cannes (Marcet, 1874-77) | 53·6 | 48·2 | 50·23 | 48·5 | 50·7 | 55·7 |
| Mentone, (Farina and Castillon, 1861-77) | 55·3 | 50·55 | 49·9 | 50·6 | 53·9 | 58·7 |
| *Relative Humidity* | | | | | | |
| San Diego (1871-83) . | 66·4 | 67·2 | 71·2 | 74·3 | 75·5 | 72·4=71·16 |
| Cannes (de Valcourt, 4 years, 1865-68) | 59·0 | 63·0 | 69·0 | 63·0 | 57·0 | 62·0 |
| Cannes (Marcet, 6 years) | 71·2 | 72·7 | 71·7 | 75·0 | 73·1 | 74·3=73·0 |
| Mentone (D. A. Freeman, 2 and 3 years) | 75·0 | 72·0 | 72·0 | 70·0 | 74·0 | 74·0=72·8 |

The mean daily range of temperature at San Diego is 14·3° F. for the year, 17·3° F. for January, and 11·6° F. for July.

sake of comparison the relative humidity and the mean temperature of San Diego, of Cannes, and of Mentone for the six winter months may be put in the form of the preceding table.

In San Diego, as throughout the rest of California, rain falls almost exclusively in winter. In the three months December, January, and February there are on an average more than 67 clear and fine days; and even on cloudy or rainy days it is usually possible to be out of doors for some hours.

The table on the next page, compiled from Dr. Huntington Richards' figures in the *Reference Handbook of Medical Sciences*, will show more in full the details of the climate of San Diego.[5]

### Santa Barbara

Santa Barbara lies in the 34th degree of north latitude—that is, about 2° south of Algiers and less than 2° north of Madeira. It occupies a valley in the foot-hills of the Santa Ynez Mountains, and stands about a mile back from the shore. Lying a little more than 50 miles below Point Conception, where the coast takes an easterly bend, the town is fairly well protected from north winds by the St. Ynez Range. It is pleasantly situated, and the hills around give it a picturesque aspect. Its water-supply is good, and its general sanitary arrangements appear to be satisfactory.

The amusements of Santa Barbara are mostly of an outdoor description—such as riding, fishing, boating, and bathing. Riding-horses are easily to be had at a cheap rate.

In climatic features Santa Barbara closely resembles San Diego, the points of difference being a slightly lower, and a somewhat greater range of temperature, and a somewhat less degree of humidity, and perhaps more wind. Like all the rest of the coast line in California it is suitable for summer as well as for winter residence.

### Monterey

Monterey lies on the coast about 80 miles south of San Francisco, and is well protected, owing to its position in the Bay of Monterey. The large hotel—Hotel del Monte

San Diego—12 Years. Hours of Observation: 7 A.M., 3 P.M., 11 P.M.

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature | 53·6 | 54·3 | 55·6 | 57·7 | 60·9 | 64·4 | 67·1 | 68·7 | 66·8 | 62·8 | 58·2 | 55·6 | 60·4° F. |
| Mean daily range | 17·3 | 15·3 | 13·8 | 14·1 | 13·2 | 12·8 | 11·6 | 11·8 | 14·1 | 15·2 | 18·1 | 15·5 | 14·3° F. |
| Range of temperature for the period | 46·0 | 47·6 | 61·0 | 48·0 | 48·6 | 43·0 | 32·0 | 32·0 | 51·5 | 48·0 | 47·0 | 50·0 | 69° F. |
| Relative humidity | 71·2 | 74·3 | 75·5 | 72·4 | 73·0 | 73·8 | 76·4 | 77·1 | 76·4 | 71·5 | 66·4 | 67·2 | 72·9% |
| Average rainfall in inches | 1·85 | 2·07 | 0·97 | 0·68 | 0·26 | 0·05 | 0·02 | 0·23 | 0·05 | 0·49 | 0·70 | 2·12 | 9·49 |
| Fair and clear days | 22·5 | 20·3 | 21·4 | 22·1 | 20·1 | 21·9 | 24·3 | 26·3 | 25·6 | 25·4 | 23·5 | 24·4 | 277·8 |
| Direction of wind from | N.E. | N.W. | W. | W. | W. | W. | W. | W. | N.W. | N.W. | N.W. | N.E. | W. |
| Average velocity of wind in miles per hour | 5·1 | 6·0 | 6·4 | 6·6 | 6·7 | 6·3 | 6·3 | 6·0 | 5·9 | 5·4 | 5·1 | 5·1 | 5·9 |

—is very beautifully situated in a magnificently wooded park, and within a few hundred yards from the ocean. It is a favourite resort for persons from the Eastern States during the winter, and for the San Franciscans during summer. It is visited not so much by invalids as by people who wish to escape the extremes either of heat or of cold belonging to their own climate. Monterey has a somewhat cooler climate than has either Santa Barbara or San Diego. It is also fairly well protected from wind.

### Los Angeles

Los Angeles is the most thriving city of California south of San Francisco. It has an elevation of 283 feet above sea-level, and is about fourteen miles from the coast. In 1888 it had a population of a little over 11,000, in 1890 over 50,000, and in 1900 over 102,000.

It has to an unusual extent the active, thriving appearance of western towns generally—fine broad streets, well-kept, good shops, and magnificent buildings, and an excellent service of electric tramcars.

The soil is clayey and the water-supply is not particularly good. The sanitary arrangements, too, are still capable of considerable improvement, and typhoid fever is not unknown in the thickly populated parts of the town.

In climate Los Angeles, while partaking of the features common to Southern California generally, is a typical example of the inland climate as distinguished from that of the coast. The mean temperature for the year is almost the same as for the places already described; but the heat in summer and the cold in winter are greater than in the coast stations. The relative humidity is considerably less,—63·6 for the winter,—fogs are very much less frequent, and the number of rainy days is fewer. Los Angeles is also comparatively free from strong winds; and unlike many other Californian resorts it does not appear to be unpleasantly affected by the wind in summer. The average velocity of the wind is five miles an hour. The annexed table, compiled from Dr. Huntington Richards,[6] gives more details.

LOS ANGELES—$6\frac{1}{2}$ Years. Hours of Observation: 7 A.M., 3 P.M., 11 P.M.

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature . | 52·2 | 53·2 | 55·6 | 57·9 | 61·7 | 65·5 | 68·0 | 69·2 | 67·8 | 62·5 | 57·9 | 55·0 | 60·5° F. |
| Mean daily range . | 20·1 | 19·2 | 19·1 | 20·2 | 22·5 | 21·9 | 23·1 | 24·2 | 25·2 | 24·0 | 24·5 | 20·9 | Deg. Fahr. |
| Range of temperature for the period | 52·0 | 58·0 | 63·7 | 55·0 | 60·5 | 56·5 | 46·9 | 49·8 | 59·5 | 54·0 | 51·8 | 58·2 | 75·5° F. |
| Relative humidity . | 62·9 | 66·3 | 71·9 | 70·1 | 69·1 | 69·1 | 69·4 | 68·9 | 68·4 | 64·0 | 57·3 | 61·5 | 66·6% |
| Average rainfall in inches | 2·05 | 2·78 | 1·95 | 1·73 | 0·60 | 2·02 | amount | inappr | eciable | 0·62 | 0·95 | 3·82 | 14·52 |
| Fair and clear days . | 26·0 | 22·5 | 23·3 | 22·7 | 25·3 | 25·7 | 30·1 | 29·7 | 28·7 | 28·0 | 28·1 | 26·0 | 316·1 |
| Direction of wind from | N.E. | N.E. | W. | W. | W. | W. | W. | W. | W. | W. | N.E. | N.E. | ... |
| Average velocity of wind in miles per hour | 5·5 | 5·7 | 5·2 | 5·4 | 5·4 | 5·1 | 4·9 | 4·5 | 4·6 | 4·8 | 4·9 | 5·0 | 5·1 |

Los Angeles has become an important business centre for the extensive fruit district in which it stands, but can hardly be regarded in the light of a health resort, though not an unsuitable place for many a man in delicate health who might be unable to live elsewhere. It is, moreover, a useful centre for excursions into other portions of the country, if one thinks of settling down in the State.

### Pasadena

Pasadena is seven miles north-east of Los Angeles, and about twenty miles from the coast. It stands at an elevation of about 1000 feet above sea-level. It has a light and dry soil, and a good water-supply. In climatic features it very closely resembles Los Angeles, but it is practically free from fog. The atmosphere also has less relative humidity, but precise observations are lacking in regard to these points.

Pasadena is one of the most important health resorts in Southern California, and is a good type of the inland variety. It is free from most of the drawbacks that render Los Angeles unsuitable for an invalid, and apart from its own attractions it has the benefit of excellent communication with Los Angeles, trams running frequently. The hotel accommodation is of the highest quality. The surrounding country is very beautiful, and orange groves and sweet-scented trees give the air a deliciously balmy fragrance.

Pasadena is what is known as a religious town—churches and chapels of every sect are seen in great number, and the Sabbath is observed almost as strictly as in Scotland.

Santa Monica and Redondo Beach are small resorts on the coast, but in the immediate neighbourhood of Los Angeles. Redondo Beach has the advantage of a very fine hotel.

For what cases is California adapted? Owing to the variety of climates found within the borders of the State there are few invalids, whatever may be their ailment, who could not there find a suitable home. Unfortunately for invalids the country is not laid out with the special view of attending to their needs. In spite of its warmth the air can hardly be considered relaxing. The resorts on the immediate

coast, such as San Diego, being less subject to violent winds and to extreme temperatures, are appropriate for the majority of persons, suffering from pulmonary phthisis, who seek the climate on account of health. Unless the strength be too far gone, the invalid is able in these places to spend the greater portion of the day the whole year round in the open air.

California is especially suitable for persons of moderate vitality, who have little or no active disease, but who have a predisposition to pulmonary trouble, and who would be likely to break down under the wear and tear of life in England or in the larger cities of the Eastern States of America. To such persons California offers an excellent prospect not merely of being able to live, but of being able to gain a livelihood. Throughout the country, but especially in the southern portion of the State, fruit-growing—chiefly of oranges and lemons—affords a chance of profitable investment for small capital. The work that is required in fruit-growing is suitable for people not exactly invalids, but hardly able to do the full amount of a daily labourer's output. In orange-growing a certain amount of occupation may be had the whole year round, and, while not laborious, it is always in the open air and extremely healthful.

In order to succeed in a business of the kind the same energy and perseverance are necessary that are required to ensure success in other pursuits of life. While California offers great opportunities for the profitable investment of small capital, there is perhaps no country in the world that offers greater inducement for the unprofitable investment of it; and any one intending to settle in the country should, before purchasing land, spend at least eighteen months or two years in making himself acquainted with the value of land generally throughout the country, and with the special merit of the piece he intends to buy. Owing to syndicates and "booms" land is constantly changing in price, and one's best friends will advise one to invest capital in schemes in which very soon afterwards they lose their own money. In California perhaps more than in any other State in the Union the newcomer, or "tenderfoot" as he is called, is

looked on as fair game, specially sent by Providence to help those who were themselves fleeced when new-comers.

It may not be out of place to give a word of warning in regard to sending out young men to a ranche on what is known as the pupil system. During the course of a visit to California I became acquainted with an instance where the proprietor of a fruit ranch represented himself by an advertisement in the London *Times* as willing to take pupils, and as giving board, lodging, and instruction in farming, in addition to general supervision to the young man in return for a good premium. The young men so received were required to do menial labour that other less wily proprietors had to pay Chinese to do. They were encouraged to spend their time in drinking and dissipation; and in the end some committed suicide, and others sank into various forms of degradation. Strangely enough the man who has carried on this nefarious traffic has never, so far as I know, been exposed, and he still continues to swindle parents and to lead their sons to ruin.

Owing to the mildness of its climate, the moderate degree of its humidity, and the absence of extremes of heat and of cold, Southern California is suitable for a greater variety of invalids than is any other country of similar size in the world. The heat is seldom oppressive, and the cold is rarely so great as to be trying even to delicate invalids. The days, even when warm, are succeeded by cool evenings, which to most people form a refreshing contrast.

One of the serious drawbacks of Southern California as a place of permanent residence, however, lies in the sparseness of the population except in the towns and their immediate neighbourhood. One may have very nice neighbours, but require half-a-day to visit them.

In spite of the general testimony in favour of the climate in California there are not lacking criticisms and statements to the opposite effect. Dr. T. D. Meyers, after a residence of five years in different parts of the State, finds serious objections to California for consumptives, both in winter and in summer. In summer the dryness, the dust, and the wind,—in winter the high degree of humidity, the

severe cold winds, and the difference between sunshine and shade,—are complained of. The hot dry winds of summer, moreover, have a depressing influence on the nervous system, while the alkaline dust which they carry into the air is irritating to the mucous membrane of the respiratory passages.

That drawbacks exist is beyond question. What weight must be attached to these drawbacks? In all probability the wind and the dust are less trying in South California than in the mountain resorts of Colorado or on the Mediterranean coast of France. The humidity of the winter climate can be avoided by adopting one of the inland stations, such as Pasadena, while the excessive dryness of the summer is not found on the coast line. There is no climate in the world without drawbacks, but fewer climatic disadvantages for permanent residence are probably to be found in South California than in any other country under the sun.

Hay fever is said not to originate in California, and patients suffering from the ailment are stated to get much relief there. It is said also that asthmatics, as a rule, are benefited. In regard to rheumatism the evidence is conflicting, but the preponderance of testimony goes to show that rheumatic cases do well in Southern California generally. Renal trouble seldom occurs, and persons suffering from disease of the kidneys may go to Southern California with advantage. The climate is suitable, moreover, for old people and for persons broken down by overwork.

### Florida

The peninsula of Florida, forming the south-eastern extremity of the United States, had in days gone by a high reputation as a winter resort for consumptives. This was easy to understand when a warm, moist, and equable climate was regarded as most suitable for such cases. With the progress of knowledge, and with experience drawn from health resorts of quite opposite stamp, Florida has to a great extent lost its old renown. At the same time the character of its climate, the peculiar charm of its

scenery, and its marvellous hotel accommodation will always render it attractive to certain people and suitable for certain classes of invalids.

Florida is about 400 miles in length and about 120 miles in breadth, except at the extreme north, where its breadth is almost as great as its length. The whole country is extremely flat, its highest point probably not exceeding 300 feet in elevation, and the great mass of the country being less than 100 feet above the level of the sea. The soil is mostly of a sandy character, but in many of the inland swamps it is mixed with a kind of clay. Lakes and pools and swamps occupy a very large part of the interior of the country and almost the whole of the southern portion of Florida. Between these swampy districts the soil is cultivated and yields grain in moderate abundance and fruit of almost every variety. The vegetation throughout the country is of a tropical character, and along the swamps and sluggish-flowing rivers it is of a picturesque but rank description, and very suggestive of the malaria which in the warmer months of the year forms a great drawback to the inland portion of the country.

The chief places of winter resort are Jacksonville and St. Augustine, on the Atlantic coast, near the northern extremity of the State, and Tampa, on the western or Gulf coast, about two-thirds of the length of the State southwards.

These three resorts have certain features in common, but Tampa is distinguished from the other two by a higher temperature, and by greater equability of temperature, as well as by a somewhat moister air and by comparative absence of sea breezes, which occur in the eastern resorts even in the hottest weather.

These peculiarities of Tampa, the west coast resort, are due to the neighbourhood of the warm waters of the Gulf of Mexico, which bathe the whole of that coast and warm the breezes that blow landwards.

Only during two or three months of the year is Florida visited by persons who wish to escape the great cold and piercing winds of the more northern States. The arrivals

are very few before the middle of January; the season is in full swing in February, and by the end of March the numbers are again on the decline, the chief hotels closing their doors in the middle of April.

During the three months January, February, and March the mean temperature in St. Augustine and Jacksonville is very nearly what would be found in Ventnor during June, July, August, and September. The range of temperature is, however, greater in Florida. In addition to this greater range of daily temperature waves of heat and of cold are apt to occur. There may be a succession of hot, sultry days when the mercury reaches 80° F. in the shade, and this may be followed by a spell of cold weather when the thermometer falls to freezing-point, or very near it, during the night. During these cold waves windstorms from the north-east not infrequently add to the discomfort. This inequability of temperature and liability to "cold days" is a characteristic of the climate of the whole of the United States east of the Rocky Mountains, and Florida suffers in this respect probably less than any other eastern State, so that in spite of the drawbacks it offers a refuge of comparative security from the more inclement winter season of the north.

The mild temperature is the chief characteristic of the winter season in Florida. In addition there is a considerable amount of sunshine, and the air is, though not dry, by no means excessively moist. The sea breezes in St. Augustine are complained of by some invalids, and as the soil is formed of a light sand, dust often aggravates this disadvantage.

The accompanying table, compiled from the article by Dr. Huntington Richards[7] in the *Reference Handbook of Medical Sciences*, gives meteorological details of Jacksonville.

The health of Florida during the winter months is tolerably satisfactory. St. Augustine itself is free from malaria, and during the winter even the inland districts are tolerably safe. The general sanitary arrangements of St. Augustine are fairly good.

Jacksonville, Florida—12 Years. Hours of Observation: 7 A.M., 3 P.M., 11 P.M.

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature . | 58·8 | 58·1 | 62·7 | 69·0 | 75·3 | 80·7 | 82·5 | 81·0 | 77·8 | 70·0 | 61·7 | 55·8 | 69·2° F. |
| Mean daily range . | 16·7 | 16·4 | 17·4 | 16·9 | 16·1 | 15·6 | 16·1 | 15·0 | 13·8 | 13·3 | 15·6 | 17·0 | 15·8° F. |
| Range of temperature for the period | 56·0 | 51·0 | 57·0 | 54·0 | 50·5 | 38·5 | 32·4 | 34·0 | 42·0 | 52·0 | 54·0 | 62·0 | 85° F. |
| Mean relative humidity | 74·6 | 70·6 | 65·4 | 67·2 | 68·3 | 70·8 | 71·8 | 74·4 | 77·4 | 74·9 | 74·8 | 73·7 | 72 per cent. |
| Average rainfall in inches | 3·28 | 3·45 | 3·13 | 3·55 | 3·80 | 5·39 | 5·18 | 7·19 | 7·27 | 6·60 | 2·95 | 2·89 | 54·68 inches. |
| Fair and clear days . | 21·8 | 20·1 | 25·7 | 23·8 | 25·5 | 23·5 | 26·2 | 26·0 | 21·4 | 22·8 | 20·9 | 22·2 | 279·9 days. |
| Direction of wind, from | N.E. | N.E. | S.W. | S.W. | N.E. | S.W. | S.W. | N.E. | N.E. | N.E. | N.E. | N.E. | N.E. |
| Velocity of wind in miles per hour | 5·8 | 6·9 | 7·9 | 7·6 | 6·7 | 6·9 | 6·3 | 6·2 | 6·4 | 6·9 | 6·5 | 6·0 | 6·7 |

Jacksonville, the most important town of the State, though not the capital, has a population (in 1900) of more than 28,000 inhabitants. It is the business centre of the sleepy State, which throughout its entire extent strikes one as being about 150 years behind the rest of the great country to which it belongs.

St. Augustine is well supplied with hotels—one, the Ponce de Leon, being one of the finest establishments of the kind in the world.

Now, for what class of cases is Florida suitable?

In former days its chief merit was supposed to be for consumption. The reader who has assimilated the principles laid down in this book will readily see that no general statement can be made as to the climate suitable for consumption. No climate is suitable for the disease *per se*—a climate is suitable or not suitable for the patient according as it suits his general health. People who have not stamina enough to react to the stimulus of a cold climate, and whose organs are unable to respond to the extra demand thus thrown on them, may do well in the mild air of Florida. The prospect in these cases is at the best not very favourable, but their chance, whatever it is, is better in a mild climate where the demands are not beyond the resources of their organism. In St. Augustine or in Tampa patients of that description can spend a great amount of time in the open air, and can thus prolong and even enjoy a life that would be embittered as well as shortened in a cold country or in a high altitude.

The tendency in our days is unfortunately to send all patients whose ailment bears the label of consumption to one resort or to one type of resort. At one moment fashion favours high altitudes; at the next moment she sends patients in flocks perhaps for a sea-voyage, perhaps to a damp, and it may be windy, sanatorium. But this indiscriminate practice is radically unsound, and leads in many cases to disastrous results, which a small amount of reflection on the principles involved would suffice to avert. Florida and the kindred warm climates have unjustly fallen

into neglect. For a certain class of cases they still offer, and always will offer, the best prospect, not merely of soothing life or of prolonging it, but even of securing entire recovery.

## Asheville

Asheville, a small town of between 2000 and 3000 inhabitants in North Carolina, has within the last twenty years or so attained considerable reputation as a winter resort for consumptives. Long before then it was popular among people of the South as a place of refuge from hay fever and from the great heat of the Southern summer.

Asheville is situated on an elevated plateau of the Appalachian chain in the extreme west of the State. The plateau on which it lies is about 175 miles in length and from 10 to 50 miles in breadth, and has an elevation of about 2000 feet. The town itself has an elevation of 2250 feet, but a portion of the plateau farther north lies from 1000 to 1500 feet higher.

The Blue Ridge Mountains on the east and the Great Smoky Mountains on the west afford a considerable amount of shelter. At the same time they are not so close as to interfere with the sunshine or to cause a downdraft of cold air—a condition apt to occur where a valley is immediately surrounded by high mountains.

The whole of the country is hilly, but the mountains nearest to the town are at least ten miles off. A dense growth of forest trees extends from the immediate neighbourhood of the town almost to the summits of the surrounding mountain peaks, many of which attain an altitude of 6000 feet. The hilly character of the country, the abundance of woodland, and the presence of a great many mountain streams combine to render the whole district one of the most beautiful in the United States.

Some details of the meteorological features of Asheville are given in the form of a table, compiled from Dr. Huntington Richards[8] in the *Reference Handbook of the Medical Sciences.* It represents a small number of years (from two to thirteen):—

ASHEVILLE, N.C. 35° 27′ N. lat., 82° 29′ W. long. 2250 feet above sea-level. Observations: 2-13 Years.
By Dr. J. W. GLEITSMANN, New York.

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temperature, 13 years (1867-1879) | 37·70 | 39·40 | 45·50 | 53·90 | 61·70 | 68·80 | 72·60 | 70·60 | 63·70 | 53·60 | 44·60 | 37·80 | 54·10° F. |
| Mean daily range for 1878 | 15·31 | 14·62 | 19·58 | 18·16 | 20·35 | 20·17 | 18·50 | 16·23 | 16·91 | ... | ... | ... | ... |
| Absolute daily range for 1878 | 26·50 | 30·00 | 33·50 | 31·20 | 35·60 | 36·00 | 27·40 | 26·10 | 28·00 | ... | ... | ... | ... |
| Absolute monthly range for 1878 | 50·00 | 41·50 | 43·50 | 42·10 | 46·70 | 40·70 | 30·70 | 27·80 | 37·20 | 47·00 | 39·00 | 46·00 | 50·00° F. |
| Absolute monthly range for 1879 | 68·30 | 50·50 | 45·20 | 53·50 | 53·00 | 43·00 | 41·00 | 36·00 | 44·50 | 51·00 | 58·20 | 54·00 | 68·30° F. |
| Rainfall, eleven years (1869-1879) | 2·62 | 3·69 | 4·30 | 3·43 | 3·50 | 4·21 | 4·88 | 4·62 | 2·32 | 3·05 | 2·90 | 3·03 | 42·55 inches. |
| Fair and clear days, two years (1878-1879) | 17 | 16 | 25 | 20 | 29 | 23 | 21 | 20 | 22 | 25 | 23 | 18 | 259 days. |
| Mean relative humidity, four years (1876-1879) | 67·13 | 64·97 | 59 51 | 62·13 | 68·67 | 75·26 | 78·56 | 80·13 | 79·96 | 71·87 | 66·38 | 71·92 | 70·32 per cent. |

The winter is cold—the mean temperature of January being 37° F. The mean daily range is comparatively small, about 15° F. for January and February, but Asheville, like so many other places in the United States, is liable to very great alternations of temperature. During four years the range in January, for example, extends from over 69° F. to 6° F. below zero. The relative humidity varies from 67 per cent in January to more than 78 per cent in July. The cloudy days number about 14 in January, 10 in April and in July, and 6 in October.

Snow, when it falls, rarely remains many days on the mountains, or even many hours.

The soil for the most part is red clay, in some places mixed with sand, and, in spite of deep mud at times, it dries quickly.

Dr. Gleitsmann, writing in 1885, says: "I did not say anything about drainage, as there was none when I was there, and probably never will be an artificial one, the town and whole surrounding country being hilly."

Good water is brought in pipes from a distance.

Good hunting and fishing are to be had within ten or fifteen miles.

As already said, Asheville has long been known as a summer resort; but only within recent years have consumptives flocked thither. Reports have been published showing favourable results in incipient cases. The cases best suited are those who have strength enough to take a fair amount of exercise in the open air, and whose disease is not in a very advanced or active condition. The cases that on account of cardiac disease, emphysema, etc., are unsuitable for a high altitude—for which otherwise they might be fit—are likely to get on well here.

Malaria is unknown in Asheville, and cases suffering from the consequences of this disease are said to do specially well here.

Aiken, a small town in South Carolina, stands at an elevation of 565 feet above sea level, and within recent years has become a place of resort for consumptives during

the winter. The soil is almost exclusively sandy, and hardly any of the smaller plants will grow in it without the aid of fertilizers. Near the town and in all the surrounding country, however, pine trees of various kinds are found in great abundance. Owing to the forests formed by these trees, the climate of Aiken is sheltered from wind and fairly equable in temperature. The relative humidity appears to be low.

There is no artificial drainage in Aiken—a drawback of less serious consequence than it would be if the soil were of a different character.

The mean temperature in January is about 48° F., in April 63; the mean daily range is from 12° to 19° F. The rainfall in winter is 10·3 inches, in spring 12·8 inches.

Aiken is said to be quite free from malaria. Owing to the dryness of the atmosphere rheumatic cases are said to do well. Cases of naso-pharyngeal and of laryngeal catarrh are stated also to be benefited.

The hotel accommodation is excellent.

Thomasville in Georgia has a climate very much resembling that of Aiken, but it is moister and not so cold.

It is suitable for the same class of cases.

### The Adirondack Mountains

The Adirondack Mountains, in the western portion of the State of New York, lie to the west of Lake Champlain. The mountains occupy an elevated plateau, nearly 2000 feet high, and many of the peaks reach an altitude of more than 4000 feet, the highest being 5337 feet.

The country is thickly wooded throughout with pines of many varieties, and owing to the great abundance of small lakes and forests the whole district has a character of great beauty.

During the summer months the Adirondacks are largely resorted to by fishermen, and, in fact, by sportsmen of all kinds.

Dr. Trudeau, to whom the Adirondacks owe their reputation as a health resort in phthisis, says: "There is no marked preponderance of clear days at any season; on the contrary, the sky, especially in winter, is constantly overcast. This cool cloudy weather is a marked feature of the climate. The soil is very light and sandy, with here and there rocks, but little or no clay."

The winter is cold, the summer is stated to be cool, though during a short visit that I paid to this region in the month of June, the heat was simply oppressive.

Dr. Loomis regards the Adirondack region as suited to cases of "catarrhal phthisis." "Tubercular cases" he considers unlikely to derive benefit from climatic cure (Richards, *Reference Handbook of the Medical Sciences*). The pathology of the foregoing sentences is evidently of a pre-bacillary type, and is not altogether easy of interpretation.

Dr. Trudeau's sanatorium, on the cottage system, near Saranac Lake, 1539 feet above the sea, probably deserves most of the credit usually ascribed to the district.

### REFERENCES

1. Compiled from articles on Denver and on Colorado Springs by Dr. Huntington Richards in *A Reference Handbook of the Medical Sciences*, New York, 1886, vol. ii. pp. 404, 405, and 238.
2. Huntington Richards, *loc. cit.* pp. 236-238.
3. E. S. Solly, *A Handbook of Medical Climatology*, London, 1897, p. 257.
4. Lorin Blodget, *Climatology of the United States*, Philadelphia, 1857, pp. 198-199.
5. Huntington Richards, *op. cit.* vol. vi. p. 259, also vol ii. p. 238.
6. Huntington Richards, *op. cit.* vol. iv. p. 581
7. Huntington Richards, *op. cit.* vol. iv. pp. 234-238
8. Huntington Richards, *op. cit.* vol. i. p. 385.

# CHAPTER XXI

## ALPINE MOUNTAIN RESORTS

WITHIN the last forty years a new class of health resorts, represented by the Alpine stations, has sprung into existence. Their common characteristic is their high elevation above sea level. During summer, and in the Tropics, the cooler air of the mountains had always been sought as a refuge from the greater heat of the plains. But within the last forty years great altitudes have been selected for winter residence, even in countries far removed from the Tropics, where winter in the lowlands had hitherto been avoided by invalids. The winter at great heights in the mountains must, it was thought, be infinitely more severe. What advantage had it then, and how could invalids, unable to stand the ordinary lowland winter, endure the intense cold of snow-covered valleys in lofty mountains ? The explanation lies in facts already set forth. In the Swiss Alps the air in winter is cold and dry. In many valleys there is hardly any wind during the cold season. In addition there is usually abundance of sunshine. Invalids who suffer from the penetrating damp and windy cold of their lowland homes, often enjoy the intenser cold from which, owing to its dryness and stillness, they can efficiently protect themselves.

It was not on theoretical grounds that mountain resorts first came into vogue. Jourdanet, a French physician resident in Mexico, noticed an absence or extreme infrequency of phthisis among the inhabitants of the elevated region in which he practised. The rarity of the disease

was all the more striking from its prevalence at lower levels in the same country. Archibald Smith made the same observation in Peru. Brehmer established a sanatorium in the low mountains of Silesia, claiming that in northern latitudes the same effects were obtained as at higher altitudes near the Equator. Spengler of Davos in 1862 informed Meyer Ahrens of the rarity of consumption amongst inhabitants who had not quitted their native valley, and of the frequent recovery of those who returned affected with the disease from foreign countries. In 1865 Spengler published his observations; and in 1865 two tubercular patients, who still live, came up to spend the winter in the mountains. From that time on Davos has steadily grown, and numerous other resorts of the same type have sprung up elsewhere.

The most important Alpine winter resorts besides Davos are St. Moritz, Arosa, Leysin, Les Avants, and Caux. Grindelwald and Chateau d'Oex, long known as summer resorts, have within the last few years received winter visitors also, but do not lay themselves out specially for invalids.

Clavadel is to be regarded as belonging to Davos, from which it is only a little more than two miles distant.

The elevated resorts in America—Colorado in North America, and many other high-lying places in the Rocky Mountains—have been mentioned elsewhere. The great high plateau of South Africa belongs essentially to the group now under observation.

### Davos

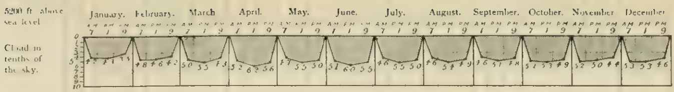
Davos-Platz is situated near the upper end of a valley about 16 kilometres or 10 miles in length. The highest point of this valley at Wolfgang has an elevation of 5357 feet above sea level; the Davos Lake, 5121 feet; the lowest bridge in the gorge on the road to Wiesen, 4200 feet. The valley runs down from north-east to south-west. The health resort of Davos may be said to embrace the upper part of the valley from Wolfgang to Frauenkirch, including the Schatzalp, where a sanatorium stands at an

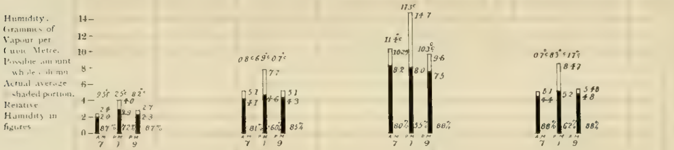
elevation of 6120 feet above sea level, and Clavadel, with its sanatorium, at an elevation of 5525 feet near the entrance of the Sertig valley opposite Frauenkirch, which is 5052 feet above sea level. This upper portion of the valley is about half a mile wide, and mountains rise on each side from about one to three thousand feet above the valley. The mountain sides are covered with pine trees up to a level of about 7000 or 8000 feet above sea level. The villages lie mainly on the north-eastern side of the valley, and thus have a south-western exposure.

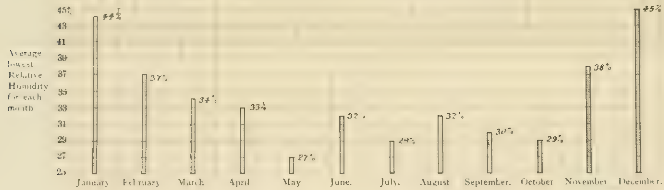
A small lake occupies the upper or north-eastern portion of the valley. The outflow from it uniting with the stream from the Flüela Pass, forms the Landwasser river, which runs down the valley ultimately to join one of the main tributaries of the Rhine. The Landwasser used at one time to take a winding course, and after rain-storms it often overflowed its banks and flooded the valley. In 1885 it was canalised; its bed deepened, and its course straightened. If less beautiful it is at any rate more useful. At the time of the canalisation a main-drainage system was introduced. An abundant supply of running water keeps the pipes constantly flushed. The solid matter is deposited in receptacles, while the liquid portion enters the rapid stream and is carried away.

The population of Davos during the full season is between 8000 and 9000. Of these rather more than half are Swiss, and rather less than half are foreigners. Of the Swiss about one-third are burghers of Davos, one-third come from other parts of the same Canton, and one-third from other Cantons of Switzerland. Of the foreigners about one-third have taken up their residence permanently in Davos. Between 17,000 and 18,000 strangers, of whom nearly 3000 are British, visit Davos in the year. In summer Davos is quiet, the chief amusements being picnics, lawn-tennis, and croquet; but in winter there is a good deal going on in the way of recreations and social entertainments. So much is this the case that there is a tendency for invalids without much strength of character to be led into excitement and fatigue, and to be drawn away from

DAVOS-PLATZ

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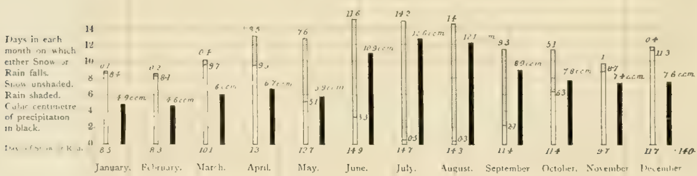


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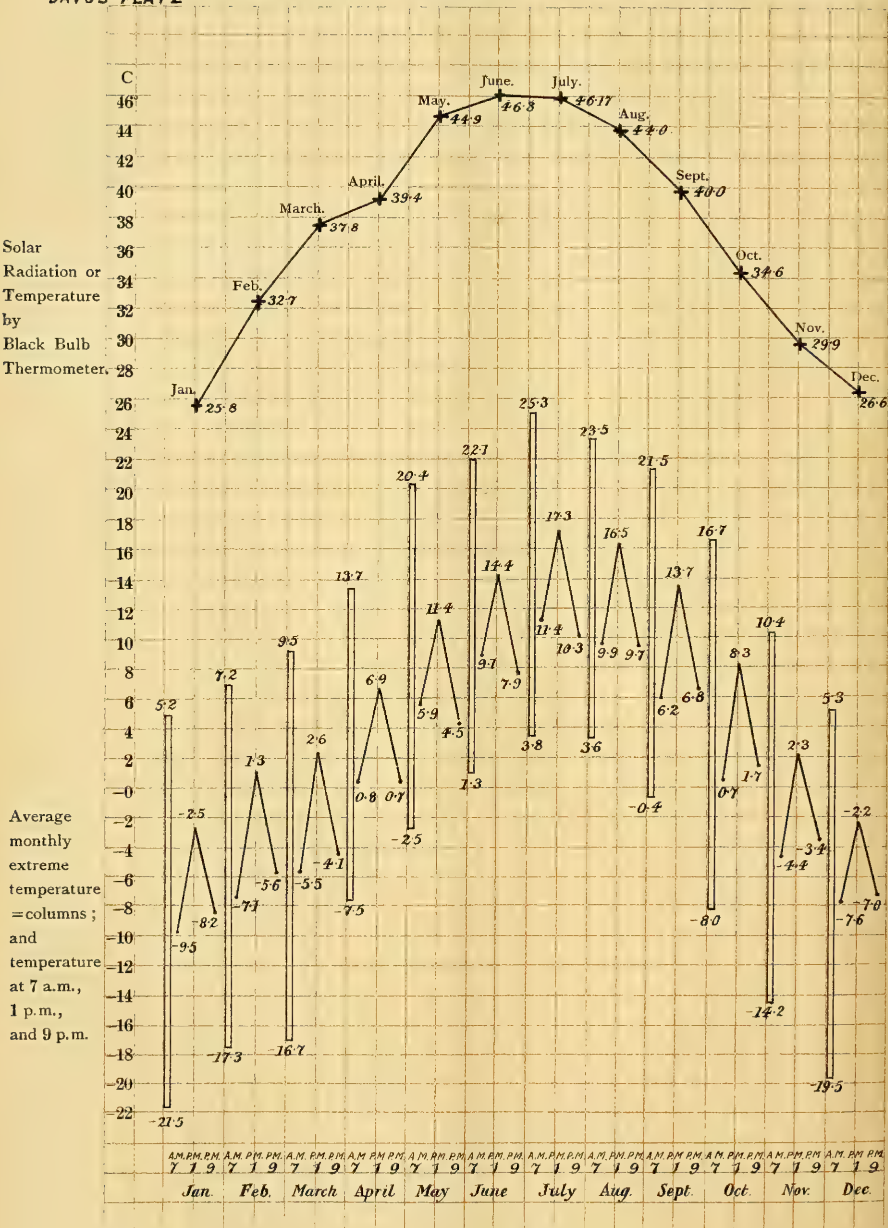

the very object for which they come to Davos. Such temptations are inevitable wherever a large number of perfectly healthy people are found, whether they come simply for a holiday or to be with invalid friends. While skating is suitable for many invalids, the rougher exercise of tobogganing is inadvisable for persons suffering from active lung disease. Within the last few years skiing has become a popular sport.

Davos is well supplied with comfortable hotels and pensions. An English library established some years ago, and growing ever since, offers a varied assortment of mental pabulum.

The journey from London takes twenty-six hours.

The following figures showing the details of the meteorology of Davos are taken from the publications of the official Meteorological Office of Davos (see p. 290).

Further information I have thrown into the form of charts. The amount of clouding in spring, summer, and autumn is about 50 per cent of the possible, and in winter somewhat less. The columns exhibiting the humidity of the air are especially instructive. They show at a glance—what is often misunderstood—the relationship between absolute and relative humidity at different temperatures. The absolute humidity is extremely low in winter, yet at the temperature then prevailing but little more water could remain in the form of vapour. In summer, on the contrary, the actual amount of watery vapour in the air is nearly three times as great as in winter, but owing to the higher temperature a larger proportion of water could exist as vapour. The relative humidity is therefore lower. It will be noticed also that while during the course of the day the absolute moisture varies but slightly, the relative moisture varies inversely as the temperature. The explanation of these changes is given in the section dealing with general meteorology.

During the summer months rain comes in frequent showers, the number of days during which rain falls and the amount of precipitation being both considerable. It

## DAVOS-PLATZ.

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Temperature— $\frac{7\frac{1}{2}+1\frac{1}{2}+2\times 9\frac{1}{2}}{4}$ | −7·4 | −4·9 | −2·7 | 2·1 | 6·6 | 10·1 | 12·6 | 11·7 | 8·7 | 3·4 | −1·5 | −6·4 | 2·6° C. |
| 1867-1900. | 18·6 | 23·18 | 27·14 | 35·78 | 43·88 | 50·18 | 54·68 | 53·06 | 47·66 | 38·12 | 29·3 | 20·48 | 36·68° F. |
| Mean absolute humidity, 1867-1900, in mm. | 2·29 | 2·64 | 3·00 | 4·12 | 5·35 | 6·92 | 8·09 | 7·92 | 7·00 | 4·66 | 3·44 | 2·53 | 4·82 mm. |
| Mean relative humidity, 1867-1900. | 83 | 80 | 79 | 76 | 72 | 75 | 75 | 81 | 79 | 79 | 82 | 84 | 79 per cent. |
| Cloudiness in tenths of the sky, 1867-1900. | 4·0 | 4·5 | 4·9 | 5·6 | 5·5 | 5·7 | 5·2 | 5·0 | 4·8 | 5·0 | 4.6 | 4·7 | 5·0. |
| Rain and snowfall in mm. of water, 1867-1900. | 46 | 54 | 53 | 57 | 58 | 102 | 126 | 125 | 94 | 67 | 55 | 61 | 898 mm. |

Snow in cm. {in year 1902 = 672 cm. ,, ,, 1903 = 607 cm.

Average number of days per year in 30 years (1867-96) on which rain or snow fell = 140 days.

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days with percentage of possible sunshine, 1886-1900— | | | | | | | | | | | | | |
| Clear days (75-100 per cent). | 13 | 13 | 12 | 10 | 8 | 8 | 12 | 14 | 13 | 14 | 13 | 13 | 143 } 200 |
| Slightly cloudy (50-75 per cent). | 4 | 3 | 5 | 6 | 7 | 5 | 5 | 6 | 4 | 4 | 4 | 4 | 57 } |
| Cloudy (25-50 per cent). | 4 | 3 | 5 | 5 | 6 | 7 | 6 | 4 | 5 | 4 | 3 | 3 | 55 |
| Covered days (0-25 per cent). | 10 | 9 | 9 | 9 | 10 | 10 | 8 | 7 | 8 | 9 | 10 | 11 | 110 |

| Wind, 1903. 3 observations daily | Calm. | N.E. | S.W. | S. | E. | S.E. | N. | W. | N.W. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 719 | 262 | 61 | 25 | 15 | 7 | 3 | 0 | 0 | times. |

will be observed also that there is not a month in the year in which snow may not occur.

The columns exhibiting the wind, compiled from Mr. Waters's statistics, show one of the most important characteristics of Davos—the stillness of the air in winter, and the increase in force and in frequency of wind in the warmer months. Mr. Waters's observations do not state the force or velocity of the wind for June and July, but it would probably be much the same as for August.

The curves and columns showing the temperature exhibit another marked peculiarity of the climate. The daily range of temperature is considerable, and the monthly extremes are very great. The marked disparity between the sun temperature and the temperature in the shade will also be noticed. That one can sit out of doors when the temperature is below freezing-point, a sunshade overhead and the feet in snowshoes, is always a source of wonder to strangers. The small amount of moisture in the air accounts both for the relatively high sun temperature and for the fact that the great cold is comparatively little felt.

The sanitary conditions in Davos are much in advance of anything to be found elsewhere in Switzerland. The drainage system has already been mentioned. The water supply is excellent. Owing to the nature and slopes of the sides of the valley, water does not collect on the surface, and the roads dry up in a marvellously short time even after the heaviest rainstorms. During the winter season, the ground being covered with snow, there is absolutely no dust out of doors. In summer the road in the immediate neighbourhood of the town is kept well watered either by rain or by the better regulated showers of the hydrant. Since 1900 there has been compulsory disinfection of rooms vacated by tubercular patients. Since 1892 such disinfection had been a matter of voluntary routine in nearly all the hotels of the English quarter. Electric lighting has displaced the old method of illumination by gas or lamp, to the great advantage of purity of air indoors. Gas is now in course of introduction for heating and cooking.

During the summer months there is a rapid and luxuriant growth of grass, yielding always two and sometimes three crops of hay. Grain does not thrive in the neighbourhood of Davos-Platz, but it grows well a little lower down in the valley. The mountain sides are clothed with pines up to about 1500 or 2000 feet above the level of the valley bottom. As soon as the winter snow disappears wild flowers come out in great abundance.

In estimating the health of a district we must closely consider the death-rate. Through the kindness of the authorities I have been allowed to inspect the local registers from their beginning in 1837. In the earlier records the cause of death, when given, obviously represents not a medical statement but a diagnosis by the relatives or by the clergyman. From 1876 a somewhat better mode of registration has been in use; but even yet the entries do not furnish sufficiently complete and satisfactory information as to the cause of death, to be made the basis of trustworthy statistics.

In these circumstances it is better not to draw up a table of the causes of death, whereby an unwarranted air of precision would be given to very doubtful facts.

Amongst the most frequently assigned causes of death are found "Altersschwäche" (weakness of age), "Lungenentzündung" (inflammation of lungs), "Gehirnentzündung" (inflammation of the brain), "Herzschlag" (heart-stroke), and "Lebenschwäche" (lack of vitality).

Inflammation of the lungs appears to be pretty evenly distributed over all ages from the first year of life on. It shared the chief place with weakness of age and apoplexy in ending the life-history of the aged. Inflammation of the brain strikes especially the young and the middle-aged; heart-stroke, the middle-aged and the old. Lack of vitality is applied in the first weeks of life.

In the older records "Auszehrung" (wasting or consumption) was a not infrequent entry; but the term, being applied to the very old as well as to the young, probably meant nothing more than general marasmus from any cause.

This appears the more probable as the entry "Lungen-schwindsucht" (pulmonary consumption) occurs also from time to time.

As to the frequency of tubercular diseases amongst the natives, the records do not afford ground for an exact estimate. But diseases of this group do not appear at any time to have been exceptional; and, so far as I can make out, they do not appear to be more prevalent now than formerly. On this point some statistics were compiled by the late Dr. Werner Aebi.[1] He reached the conclusion that the natives had not become more affected with tuberculosis since the place became a health resort. His conclusion, I think, is probably right, though the figures on which it is based are certainly wrong. It was the kindly old custom of the Davosers to include in the same list of their register all burghers who died, whether in Davos, in Russia, in America, or elsewhere. The death of a burgher who died abroad was inscribed in the list of those who died in the year when the news was received—years it might be after actual death. Though the date of death when known was given, the occurrence of such instances in the older registers necessitates the most careful scrutiny of each entry to avoid very serious error. In Dr. Aebi's statistics it is evident that the still-born—no inconsiderable number—are always included, and often some of the burghers who died elsewhere than at Davos. It would seem also that his statistics must have been compiled by some one without medical knowledge, the selection or rejection of cases as tubercular being of a distinctly arbitrary character. (On the general question of tuberculosis at high altitudes, see page 122 and *ff.*)

One great difficulty in estimating the beneficial influence of various health resorts in phthisis is that we do not know in what proportion of cases the disease tends of its own accord to get well. There can be no doubt that spontaneous recovery is a much more frequent occurrence than was formerly believed. Obsolete or healed tubercle has been found by various observers in different proportions. J. K.

Fowler[2] states that in nearly 2400 autopsies at the Middlesex Hospital, obsolete tubercular lesions were found in 219 or 9 per cent. Out of 139 autopsies of adults examined with special reference to this point, T. Harris found 38·84 per cent of seemingly healed pulmonary tubercle. Naegeli,[3] in a careful investigation, made 500 autopsies at the Zürich Pathological Institute, examining every organ, including the lymphatic glands, for tubercle, whether healed or active. He found evidence of tubercle in 97 per cent of subjects over eighteen years of age. Out of 276 of these cases the disease was healed in 111 or 47 per cent. The percentage of healed disease varied from 33 per cent between the ages of eighteen and thirty, to 58 per cent between the ages of fifty and sixty. Vibert's Morgue statistics (quoted page 473) show that in 68 per cent of tubercular cases the disease was healed.

Out of 1001 living cases examined by me, and analysed a few years ago, in which there was distinct evidence of past or present pulmonary tubercle, arrest had taken place in 292. Besides these, there were 21 in whom the prospect was good or the disease was undergoing arrest, but who were still under treatment or who were lost sight of before arrest had actually occurred.

These figures are not intended to represent the beneficial effects of mountain air, inasmuch as cases are included where the disease had already become arrested or was in process of arrest before the patient came to the mountains, and in some instances had been arrested for many years. A full analysis of these cases would be out of place here. Let it suffice to say that the cases best suited for the mountains are those with a certain amount of vigour and robustness and in whom the disease has not as yet seriously impaired the constitution generally. In other words, the cases best suited for the mountains are precisely those that have the best chance of getting well anywhere. The local condition is of much less importance than the constitutional state. If the cases are properly selected, high altitudes must inevitably show a higher percentage of recoveries than

other types of climate. A large number of invalids, however, come to the mountains every year who obviously have only an infinitesimal chance of improvement. For the most part, such persons come on their own initiative or by the advice of friends.

Incipient phthisis has the best prospect of recovery, provided the patient is otherwise suitable for the severe cold of an Alpine climate. Cases of longer standing also do well if the constitutional vigour be not much impaired. The hæmoptysis of early phthisis is no contra-indication for high altitude resorts. On the other hand, hæmorrhages in cases of long standing, with cavities, are not so likely to do well; and in such patients a mountain climate often seems to increase distinctly the liability to bleeding.

Tubercular ulceration of the larynx is in very many instances amenable to absolute rest of the voice, with or without local treatment, but in conjunction with the general influences that promote the healing of tubercle elsewhere, and does not in itself form a contra-indication for the mountains. The case is different where there is much catarrh of the laryngeal mucous membrane, which is usually aggravated by the dry and cold air. Phthisis, complicated by renal disease, is also unsuitable for a high, cold climate.

The Alpine resorts have gained their reputation by their value in pulmonary consumption, but they are not less beneficial in certain other respiratory ailments. In the thickening and contractions left by pleurisy a high altitude is extremely useful. The deeper breathing commonly required in the rarefied air tends to the gradual stretching of the adhesions.

Spasmodic or bronchial asthma is relieved in a very large proportion of cases. An advanced degree of emphysema would, however, contra-indicate the climate.

Bronchial catarrh in young subjects usually does well in Alpine resorts if the patient be otherwise suitable. In old subjects, on the contrary, the bronchial irritation is not infrequently increased.

Amongst the cases that benefit greatly from residence in

the mountains are general dyscrasic conditions left by acute diseases, whether local or general. After typhoid fever, malaria, or pleurisy the mountains are unsurpassed as a recruiting-ground. But after intestinal or other abdominal inflammations the great cold, with the rapid changes of temperature common in the mountains, is not so suitable. This is the case also after acute rheumatic fever, where vicissitudes of humidity and of temperature are apt to prove trying. In Davos acute rheumatic fever is a rare occurrence, but chronic muscular rheumatism is common. The high Alpine climate has a very beneficial influence on a gouty tendency in young subjects. This good effect is probably due to the increased metabolism called for by the greater cold. The marked influence of rarefied air in causing an increase in the number of red blood corpuscles renders high altitudes singularly efficacious in the treatment of anæmia. Anæmic patients on reaching a high altitude usually suffer from greatly increased breathlessness. As the quality of the blood improves the discomfort usually passes off.

Digestive ailments are not less common in the mountains than in the lowlands. An improvement in the appetite and digestion is one of the important signs that the climate is suitable, while impaired appetite and digestion have the opposite significance.

Diseases of the circulatory system impeding the passage of the blood through the lungs are aggravated by the rarefied air of a high altitude. Mitral valve affections, unless fully compensated, render a case, as a rule, unsuitable for the mountains. When the mischief is fully compensated, a high altitude may be tolerated without inconvenience or drawback, provided care be taken to avoid cardiac strain. Cases of aortic valvular disease do not generally suffer inconvenience from the rarefied air, and some instances of the kind I have known even to be benefited. Functional disorders of the heart are likely to do well or badly according as the climate suits the person generally or not.

Persons suffering from neurasthenia and other functional nervous disorders due to overwork or to impaired nutrition

usually derive great benefit from residence in the mountains, always provided that the climate is not otherwise unsuitable. Organic diseases of the nervous system are, as a rule, not adapted for high altitude treatment.

Renal diseases are, as a rule, best where the rate of metabolism is not high, and should therefore not be sent to the mountains. Irritability of the bladder is likely to be increased by the cold air of high altitudes.

In young girls the beginning of menstruation is sometimes delayed by the great cold of winter.

Clavadel, about half-an-hour's drive from Davos, is picturesquely situated on the side of the hill bounding the Sertig Thal on the north-east. Its elevation above sea-level is 5460 feet. It is quieter than Davos, and good accommodation can be had there at a somewhat lower cost.

Wiesen is two hours' drive from Davos, and is about 400 feet lower, its altitude being 4770 feet. It affords an agreeable change to many visitors at Davos, but it has not a clientele of its own in winter.

In the Upper Engadine and in the neighbouring side valleys are a numbar of health resorts. Some are open only in the summer ; others have a winter season also. The most important and best known of these resorts is St. Moritz. It consists of two parts—St. Moritz Dorf and St. Moritz Bad. The Dorf or village, with an altitude of 6090 feet, lies nearly 300 feet above the baths, which have an elevation of 5804 feet above sea-level.

St. Moritz is most picturesquely situated. The village looks down on a small but beautiful lake, and mountains rise on both sides of the valley. Pine trees, though not abundant, vary the scenery and afford shade from the sun.

In climate St. Moritz closely resembles Davos. In St. Moritz, as in Davos, the essential features of the climate are rarefaction, great dryness, and purity of the air, great cold in winter, with considerable daily variations in temperature when the weather is fine. The temperature in the sun is high, forming a delightful contrast with the crisp air. Owing to the dryness of the air, the cold and the oscilla-

tions of temperature are hardly noticed unless there happens to be wind, and then the cold becomes almost unendurable. Owing to the greater elevation, the rarefaction of the air is somewhat greater at St. Moritz, the mean barometric level being 616 mm. or $24\frac{1}{4}$ inches, while in Davos it is 631 mm. or $24\frac{3}{4}$ inches.

The cold is also greater, and the air in winter is not so still. This last feature is indeed the chief drawback of St. Moritz as a winter resort for pulmonary ailments. The valley wind blows from the Maloja Pass in the south-west, so that one is exposed to the wind when sitting in the sun. During the summer months the greater cold of the higher ground is in favour of St. Moritz as compared with Davos. St. Moritz has the further advantage of having somewhat fewer rainy days in summer.

Unlike Davos, St. Moritz is not open all the year round. During the summer season, from June 15 to September 15, it is thronged with tourists and holiday-makers as well as with persons who are somewhat run down in health.

A few consumptive patients also visit St. Moritz during the summer in the first instance, and remain on through the winter, the season when invalids of this class are in greatest force.

Both in summer and in winter St. Moritz is a gayer and more fashionable resort than Davos, and has a much smaller proportion of seriously ill patients.

The prevalent diseases and the death-rate of the Engadine were carefully studied by the late Dr. Ludwig. The health of the valley must be regarded as extremely good on the whole. Inflammation of the lungs, of the brain, and of the peritoneum are relatively more frequent than in the lowlands. Consumption, on the contrary, is a much less common ailment.

The therapeutic indications are much the same for St. Moritz as for Davos. The chief point is that the higher and colder ground is suitable for patients of greater vigour and vitality.

Of the neighbouring resorts, Samaden is the only one that can be said to be open in winter.

The Maloja, at the end of the valley, about two hours' drive from St. Moritz, at an elevation of 5941 feet above sea-level, is now used as a summer resort only. Some few years ago the excellent Hotel Kursaal, which may be said to constitute the resort, was kept open throughout the winter; but the experiment did not turn out financially successful.

Pontresina, 5997 feet above sea-level, in the Berninathal, a side valley of the Engadine, about an hour's drive from St. Moritz, has long been a favourite summer resort for tourists. One of its chief attractions is the nearness of glaciers, the Morteratschgletscher and the Roseggletscher.

During the last twenty years Arosa has grown into a health resort for tubercular patients. It lies at an altitude of from 5740 to 6070 feet. It is reached in less than six hours by diligence from Chur, the return journey taking only about half the time. From Davos a path which can be covered by foot in about six hours leads over the Strela Pass. Arosa is well situated and has an excellent sanatorium, besides several hotels and pensions arranged mainly for the reception of pulmonary cases.

Grindelwald, at an elevation of 3468 feet, is chiefly a summer resort, but is not without some winter visitors. It is beautifully situated in the neighbourhood of glaciers and fine mountain scenery. It has a good, bracing winter climate and is well protected from winds. Its winter visitors consist mostly of persons who, without being ill, wish to avoid the more trying weather of their own country. In summer Grindelwald is rather hot, but owing to its situation attracts a large number of tourists.

Château d'Oex, 3261 feet above sea-level, is in the Canton de Vaud, nearly two hours from Montreux by the newly opened railway. It is pleasantly situated in a valley running from east to west. Like Les Avants, it has a milder winter climate than has Davos. It is suitable only for persons who are not very ill. In summer the heat sometimes becomes excessive.

Leysin, at an elevation of 4757 feet above sea-level, in the Canton de Vaud, is about four hours' drive from Aigle,

or one hour by rail. It is above the Ormont valley, and overlooks the valley of the Rhône. It is situated on the side of a mountain, near the summit, and has three large sanatoriums for consumptives. Leysin has the same type of climate as Davos, and is suitable for the same class of cases.

Les Avants, also in the Canton de Vaud, at an altitude of 3232 feet, about an hour's drive or forty minutes by rail from Montreux, has for several years been open in the winter, and owes some of its popularity to the admirably managed hotel there. It faces south-east, and is protected from wind by mountains on the north and east. It commands a beautiful view. The climate in winter is of the same character as that of Davos, though much milder, owing to the lower elevation. In summer the heat is apt to become excessive. Patients for whom Davos is too high or too cold, but for whom a bracing climate is indicated, often thrive well at Les Avants. For invalids seriously ill, it is rather a drawback that medical advice must be procured from Montreux.

Caux, at an elevation of 3690 feet, lies above Montreux and Glion, on the opposite side of the valley to Les Avants. It differs from Les Avants in not being so well protected from wind. Caux has two excellent hotels, and is reached in about forty minutes by a cog-wheel railway from Territet. The line is open in summer to the Grand Hotel des Rochers de Naye, at an elevation of 2045 metres above sea-level.

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2. J. K. Fowler in *Diseases of the Lungs*, by J. K. Fowler and R. J. Godlee, 1898, p. 379.
3. O. Naegeli in Virchow's *Archiv*. Bd. 160, Heft 2, 1900.

# CHAPTER XXII

## THE OCEAN AS A HEALTH RESORT

THE meteorological conditions to be met with on a sea-voyage vary enormously according to latitude and according to the season of the year. On the voyage between England and Australia or New Zealand the traveller passes through a wide range of climate. Sir Hermann Weber[1] in his admirable article on "Thalassotherapie" in the *Handbuch der physikalischen Therapie,* quotes the figures obtained by a trustworthy observer who several times made the voyage from England to Australia and New Zealand, returning by Cape Horn. An abridgment of these tables I give here. Sir Hermann Weber remarks that the thermometer probably registered one degree (centigrade) too low.

MEAN OF 24 HOURS OF TWO JOURNEYS IN DECEMBER FROM PLYMOUTH TO WELLINGTON

| Day. | | Temp. C. | Temp. F. |
|---|---|---|---|
| 1 | ... | 9·1 | 48·38 |
| 5 | Teneriffe . . . . | 19·4 | 66·92 |
| 10 | ... | 27·8 | 82·04 |
| 22 | Cape Town . . . | 17·4 | 63·32 |
| 30 | ... | 5·6 | 42·08 |
| 39 | Hobart Town . . . | 16·6 | 61·88 |
| 42 | ... | 14·4 | 57·92 |
| 43 | Wellington . . . | 16·6 | 61·88 |

MEAN OF 24 HOURS OF TWO JOURNEYS IN APRIL FROM WELLINGTON TO PLYMOUTH

| Day. | | Temp. C. | Temp. F. |
|---|---|---|---|
| 1 | ... | 10·6 | 51·08 |
| 11 | Cape Horn . . . | 7·1 | 44·78 |
| 17 | Monte Video . . . | 13·8 | 56·84 |
| 20 | Rio de Janeiro . . . | 18·6 | 65·48 |
| 27 | ... | 27·8 | 82·04 |
| 33 | ... | 23·7 | 74·66 |
| 36 | ... | 18·9 | 66·02 |
| 37 | Plymouth . . . . | 20·0 | 68·00 |

By way of comparison I give also a few of the observations cited by W. S. Wilson[2] in his instructive book, *The Ocean as a Health Resort* (pages 316-329). Sir Hermann Weber's figures, it should be remembered, represent the means of twenty-four hours; Dr. Wilson's figures, the observations at noon.

TABLE I

EXTRACT FROM METEOROLOGICAL LOG OF SHIP *NEWCASTLE*, CAPT. CHAS. LE POER TRENCH (SUPPLIED BY THE METEOROLOGICAL OFFICE). ON VOYAGE FROM ENGLAND TO MELBOURNE IN AUTUMN OF 1876.

(Abridged from Dr. Wilson's *The Ocean as a Health Resort*.)

| Date. Civil Time. | Position. | | Wind. | | Barometer (corrected and reduced to 32° F.). | Temperature. | | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | Latitude. | Longitude. | Direction from. | Force, 0-12. | | Dry-bulb Ther. | Wet-bulb Ther. | |
| 1876. Oct. 15 | N. 49° 5′ | W. 5° 20′ | S.S.W. | 4 | 29·935 | 59 | 55 | Off the Lizard Point. |
| ,, 18 | 49° 10′ | 7° 20′ | W.N.W. | 2 | 29·665 | 57 | 53½ | |
| ,, 30 | 28° 45′ | 18° 10′ | S.S.W. | 4 | 29·905 | 74 | 72 | Sighted island of Ferro. |
| Nov. 10 | 13° 30′ | 22° 0′ | S.S.E. | 1 | 29·920 | 84 | 79 | |
| ,, 20 | S. 1° 55′ | 26° 25′ | E.S.E. | 5 | 29·955 | 79 | 75 | Steady trade winds. |
| ,, 24 | 14° 10′ | 28° 5′ | S. by W. | 4 | 30·050 | 78 | 74 | Losing the trades. |
| ,, 27 | 20° 0′ | 28° 55′ | E. | 1 | 30·125 | 78 | 76 | Sighted the island of Trinidad. |
| Dec. 15 | 41° 35′ | E. 19° 50′ | S. by W. | 3 | 29·555 | 46 | 46 | |
| Jan. 11 | 39 [illegible]′ | 14° 20′ | W. by [illegible]. | 5 | 29·785 | 62 | 56 | Sighted Cape Otway. |

## TABLE II

METEOROLOGICAL OBSERVATIONS TAKEN ON BOARD THE *SOBRAON* (CAPT. J. A. ELMSLIE, R.N.R.) BY E. MAWLEY, ESQ., F.M.S., DURING A VOYAGE FROM MELBOURNE TO LONDON *VIA* THE CAPE OF GOOD HOPE (TAKEN EACH DAY AT NOON).

(Abridged from Dr. Wilson's *The Ocean as a Health Resort.*)

| Date. | Latitude. | Longitude. | Distance since Previous Noon. | Barometer (corrected). | Temperature of Air in Shade. | Relative Humidity of Air. | Wind. Direction. | Wind. Force, 0-12. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| 1875. | S. | E. | Miles. | | | Per cent. | | | |
| Feb. 14 | ... | ... | ... | ... | ... | ... | ... | ... | Land last seen. |
| ,, 19 | 39° 14′ | 135° 50′ | 58 | 29·83 | 60·6 | 73 | S.E. | 2 | Moderately bright, but cool. |
| ,, 23 | 39° 12′ | 127° 0′ | 79 | 30·15 | 57·5 | 81 | S. | 1 | Dull and cold. |
| | | W. | | | | | | | |
| May 4 | 4° 31′ | 17° 18′ | 132 | 29·88 | 83·5 | 72 | S.E. by S. | 3 to 4 | Bright and very hot. |
| | N. | | | | | | | | |
| ,, 7 | 0° 7′ | 20° 59′ | 94 | 29·82 | 85·0 | 72 | N.E. | 1 to 2 | Bright and very hot indeed; heavy tropical shower 10 P.M., lightning; crossed the line this morning. |
| ,, 9 | 2° 52′ | 21° 24′ | 116 | 29·86 | 80·7 | 88 | N.E. | light airs | Dull, very close and rainy; about 1.30 P.M. a heavy storm came up astern; lost the S.E. trades. |
| ,, 13 | 6° 17′ | 23° 46′ | 94 | 29·84 | 79·5 | 78 | N.E. by E. | 4 | Bright and hot; caught the N.E. trades. |
| ,, 23 | 26° 44′ | 34° 13′ | 70 | 30·07 | 75·7 | 77 | ... | 0 | Bright and hot; dead calm; passing showers. |
| ,, 27 | 30° 18′ | 32° 40′ | 77 | 30·00 | 71·4 | 80 | W. | 1 | Bright; cool wind. |
| June 11 | 49° 22′ | 4° 55′ | 254 | 29·72 | 56·9 | 75 | ... | ... | Moderately bright; strong cold breeze; showery. Start Pt. N.E. 70 miles at noon; sight 6.30 P.M. |
| ,, 13 | Dull, cold, and showery. | | | Off Gravesend at 10 A.M.; and reached S.W. India Docks 8.30 P.M. | | | | | |

During the voyage the surface temperature of the sea was found but seldom to differ more than 1 or 2 degrees from the temperature of the air in the shade. On one day, however (6th April), in the Agulhas current, it was observed to be 6·7 higher than the shade temperature of the air.

Of the 118 days of the voyage, 78 were bright, 30 dull or cloudy, 10 moderately bright.

Rain fell more or less on 26 days, leaving 92 days which were quite fine.

Concerning voyages in a sailing ship, some graphic remarks by the late Dr. H. Coupland Taylor[3] may be quoted:—"Let us take the case of a patient sailing in a well-appointed ship in September, the most favourable time of the year for starting on a voyage to Australia or New Zealand. The patient finds himself pacing up and down deck to keep warm in the cool autumn sea-breeze, which frequently necessitates greatcoats and pea-jackets, even for the healthy. He goes down into the saloon as evening comes on, and finds such draughts there as would frighten him or his physician if on land! Here he has to remain all the evening, making the best of it; or if he finds it too unbearable, he tries to take refuge in his private cabin, which he has probably to share with one or two companions, and which he finds very close and lacking the fresh air he would obtain in an airy bedroom on shore. An equinoctial gale is not unusually met with before getting away from our coasts, with all its concomitant miseries of sea-sickness and enforced confinement to the lower regions, with its draughts or want of ventilation, the deck being probably too wet and slippery for anything but a struggle to the smoking-room with its vitiated air.

"After this a much more pleasant time usually sets in, lasting through the north-east trades, which carry the ship well into the Tropics, and during this period the patient usually greatly benefits—that is, if he has been able to brave the first fortnight at sea. But, again, he has to face another trial of his strength in the heat and moisture of the Tropics. The action of this humid heat results in lessened evaporation from the skin, and diminished exhalation of aqueous vapour from the lungs. A plethoric condition is set up, with a lassitude of the digestive and other functions. . . . If the patient has been suffering from hæmoptysis or night sweats, the former frequently returns with increased violence, and the latter are rendered much more profuse, and therefore more weakening. So real a danger are these, indeed, that not infrequently advanced cases terminate fatally in this region. The really de-

pressing effect of it may be seen clearly in the healthy, for in the great majority of them a considerable loss of weight takes place, varying from two to four or six pounds during the fortnight usually spent in the equatorial regions. The patient, having successfully passed through this region also, is now braced up again, and, if tolerably well, regains in the next three weeks the loss of weight he sustained in the preceding part of the voyage. This is a most delightful run, from about 15° S. to about 40° S., through which he is carried by the south-east trades in splendid weather, and which usually lasts till the latitude of the Cape of Good Hope is reached. And here trials again await the invalid, for not only is a heavy sea generally met with, but ice is often near at hand, and the cold so great as to give the majority of patients chills and chilblains, and render it necessary for the healthy to run about on deck or take part in athletic exercises to keep warm. The invalid, being unable to join in such pursuits, has to wrap himself up and keep himself warm as best he can while on deck, and when he has to 'turn in,' no warmth, no fire is to be obtained, and he has to seek his bunk shivering, with the hope of finding the warmth in bed which he is unable to gain elsewhere. This sort of weather lasts, more or less, till the longitude of the western point of Australia is reached, when it becomes decidedly warmer, and the patient is again able to sit on deck and enjoy the sunshine and his moderate exercise. This fair weather usually lasts at that time of the year (the early summer, December) till he arrives at his destination, more or less improved, we may safely say, according to the state in which he was when he left home; those with a predisposition to the disease, or those in the early stages of it, having frequently greatly benefited, whilst those in the later stages are usually much as they were, if not decidedly worse, or if they have not succumbed to the rigours of the voyage."

It will be noticed that Dr. Taylor speaks of chills and chilblains at one period of the voyage. There is a popular idea that one does not catch cold at sea. This idea Sir

Hermann Weber terms a deep-rooted error. In the reports of voyages he has not infrequently found the occurrence of chills, which have given rise to catarrh of the lungs or of the bowels, to pleurisy, and to rheumatic affections.

Parts of the description given by Dr. Taylor apply to the conditions met with in most sea-voyages for health.

Amongst the shorter sea-trips, the voyage to Madeira and the Canary Islands and excursions in the Mediterranean are amongst the most popular. Madeira is reached from England in from four to six days. Such tours are suitable especially for the spring and autumn months. For the summer months cruising to Norway and other places in the far north has become very popular.

Sea-voyages were formerly in great repute for persons with phthisis; but it is now recognised that except in certain well-defined instances they generally do harm. Only slight or mild cases, without fever and without active symptoms, are likely to benefit. The patients most suitable for a sea-voyage are those in whom the disease has become partly or entirely arrested. Incipient phthisis is also sometimes spoken of as proper for a sea-voyage; but the term incipient includes too great a variety of forms to be taken safely as a guide. In the early stages of the malady the future is too uncertain and too dependent on the surroundings to make travelling by ship advisable. Many cases have come under my notice where a sea-voyage has turned a threatening, into confirmed disease. Ocasionally, no doubt, the experiment turns out well; but in most instances it is attended with risk. An exception must be made to the foregoing remarks in the case of patients whose disease begins in the Tropics or other unhealthy region. For example, young men attacked with pulmonary tuberculosis in India commonly improve remarkably during the voyage home. The malaria and its consequences, which so often complicate these cases, are favourably influenced by the sea.

The sufferer from hay fever escapes his malady while afloat.

Convalescence after an acute illness is generally benefited; but the cases for which above all a sea-voyage is advisable are those of slight nervous depression from overwork or business worry. The freedom from daily cares and anxieties, combined with the lazy life on the water, enables the jaded nervous system to recover its tone. The feeling of restfulness and the motion of the ship have a delightful restorative effect—beyond what can be found in any other form of holiday.

No one should take a sea-voyage for health who is not a good sailor. Even when one is a good sailor one's comfort depends on a number of circumstances which cannot all be arranged beforehand. For an invalid a good cabin to himself is essential, both for comfort and for health. The position of the cabin, too, is not unimportant. The neighbourhood of the kitchen and of the hold will be avoided by those who do not relish unsavoury odours.

A sea-voyage, though so beneficial in the milder forms of nervous depression from overwork, is unsuitable in the severer forms, and especially in melancholia, where commonly there is a suicidal tendency.

A febrile tendency is a contra-indication for a sea-voyage. Persons who are easily upset in any way do not usually derive much benefit from a long sea-trip. Great cardiac weakness or advanced degeneration of the blood-vessels would render a sea-voyage a somewhat risky experiment.

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# PART IV

# BATHS AND MINERAL WATERS

## CHAPTER XXIII

### BATHS AND MINERAL WATERS—USED EXTERNALLY

THE term Mineral Water is applied to any water that differs from ordinary drinking-water, either by its high temperature as it emerges from the ground, or by containing a greater proportion of gas—usually $CO_2$, HS, or N—or of salts in solution. The amount of salts required to warrant the name is quite indefinite, some mineral waters containing hardly more than does hard drinking-water. The large group of so-called Indifferent Thermals are simply hot water, generally very pure and free from salts of any kind. To their temperature they owe all their virtue. The accident of being heated in the bowels of the earth instead of in a kettle does not in the smallest degree affect the character of the water. The only advantage of such waters is the convenience that arises from a large supply with uniform temperature.

A certain amount of mystery has always hung around mineral waters. In days gone by their virtues were ascribed to the influence of a presiding deity. The properties of some sulphur wells have been ascribed by local tradition to the supposed fact that the devil had been ducked in them. Even when avowed belief has been cast away, a lingering and often unconscious faith in the miraculous properties of the water still remains.

The discovery of helium and of radium in the Bath spring, and afterwards in other springs, has naturally suggested the idea that the therapeutic efficacy of the waters may be largely due to these substances. The idea is not

unlikely; but as yet there is nothing of the nature of proof.

Owing to vague tradition, and to the parade in analyses of strange and unimportant constituents, mineral waters are still more or less cloaked in mystery. In the following pages the essential points, which are few in number and not very complicated, will be explained succinctly, but with sufficient fulness for all practical purposes. As water is itself the most important constituent of all baths and springs, our first care must be to understand the physiological influence and therapeutic uses of plain water. We shall then have little difficulty in seeing how its action is modified by the various salts and gases it may hold in solution. We will examine first the physiological and therapeutic action of water used externally. Its internal employment will then be considered. The cleansing influence of water belongs to hygiene rather than to therapeutics, and does not require further notice here.

### Water used Externally—Cold Baths

Let us see how water used externally affects the production and removal of heat. The first action of cold water is to contract the surface vessels. By this means a larger volume of blood is thrown on the organs within. Experiment has shown that at the same time the tension of the arterial system rises. The action of the heart, after a momentary quickening, diminishes in frequency and increases in force. The first contraction of the surface vessels gradually gives way, and is followed by dilatation greater than what was present before the bath. This dilatation persists for some hours after the bath. The more sensitive the bather, the more marked are the first effects. The reaction occurs sooner the greater the cold.

These effects are not invariable. The uncertain element is the individual reaction. In the case of weakly or exhausted persons the first contraction of the vessels is not followed by a secondary expansion. The loss of heat is

more than the organism can make up. In such cases exhaustion and depression are complained of afterwards.

What is the effect on the temperature of the body? That depends partly on the quickness of the response to the stimulus, and partly on the effectiveness of the subsequent reaction. In a cold bath, when the skin acts quickly and the vessels contract, a change takes place in the distribution of the blood. Though the surface is cooled, the heat of the blood in the organs within either remains unchanged or becomes slightly greater, unless indeed the bath be very cold or lasts very long. For example, there is a rapid fall of internal temperature when the temperature of the bath is not more than 50° F. (10° C.), or when a bath between 68° F. and 77° F. (20° and 25° C.) lasts more than 25 minutes. The internal temperature sinks after the bath, if not during it. Later a slight compensating rise takes place. From the fact that the internal temperature of the body is not lowered, but rather raised, by cold baths of short duration, we may infer that combustion must be greater and tissue change more active. The inference is true. Experimental research has shown that in a cold bath the exhalation of carbonic acid and the absorption of oxygen are both increased. In regard to urea the testimony is conflicting; probably a slight increase of urea takes place.

The loss of heat in a cold bath is roughly proportional to the difference between the temperature of the body and the temperature of the water. Liebermeister's attempt, as follows, to estimate the proportions in figures, assumes an unwarranted precision:

| | | | | | | |
|---|---|---|---|---|---|---|
| Bath 34° C. (93·2° F.), | lasting | 15-20 min., | heat | loss | normal | |
| „ 30° C. (86° F.), | „ | „ | „ | „ | double the normal | |
| „ 25° C. (77° F.), | „ | „ | „ | „ | 3 times | „ |
| „ 20° C. (68° F.), | „ | „ | „ | „ | 5 „ | „ |

The loss is prevented in two ways from becoming excessive. As the surface of the body is cooled, the difference between the temperature of the body and that of the bath is lessened. Besides this, the contraction of the

surface vessels diminishes the supply of warm blood to the skin.

According to the temperature of the water, baths are classified as follows :—

| | | |
|---|---|---|
| Ice cold . . | 0°-5° C. (32°-41° F.) | Heat-abstracting |
| Very cold . | 5°-10° C. (41°-50° F.) | |
| Cold . . | 10°-15° C. (50°-59° F.) | |
| Moderately cold | 15°-20° C. (59°-68° F.) | |
| Cool . . | 20°-25° C. (68°-77° F.) | |
| Tepid . . | 25°-33° C. (77°-91·4° F.) | |
| Lukewarm . | 34°-35° C. (93·2°-95° F.) | Indifferent bath |
| Warm . . | 35°-38° C. (95°-100·4° F.) | Heat-raising |
| Hot . . | 38°-42° C. (100·4°-107·6° F.) | |
| Very hot . . | above 42° C. (107·6° F.) | |

The urine passed after a cold bath is often more abundant at first and of low specific gravity, but the amount excreted in the twenty-four hours is not much increased. The diuretic effect is probably due to augmented blood-pressure.

The reaction of the urine was formerly said to become less acid, neutral, or alkaline, after a cold bath; and the effect was supposed to be more marked the longer the bath lasted and the more frequently it was repeated. The same influence was ascribed to tepid and warm baths. The statement has been shown, however, by later experiments to be unworthy of belief.

On respiration the first effect of a cold bath is a sudden deep inspiration followed by a pause. The breathing then is for a short time quick and shallow, soon becoming slow and deep.

The nervous system is influenced in a marked degree by a cold bath. In this case the relation between the amount of heat abstracted and the power of reaction of the bather is of the highest importance. It determines whether the bath will have a stimulating or a fatiguing effect. A bath moderate in duration and in degree of cold, as compared with the bather's capacity for renewing the heat supply, causes a feeling of well-being and increased energy, while a bath that oversteps these limits causes a feeling of weariness, lethargy, or sleepiness.

In Schüller's[1] experiments the vessels of the pia mater were seen immediately to become distended in a cold bath. The distension lasted during the bath, and was followed by contraction or alternate contraction and relaxation. The muscles of organic life are excited to contraction. The muscular activity of the intestines, of the gall passages, ureters, bladder, and uterus is stimulated. The sense of touch is blunted; the sense of temperature sharpened.

### THERAPEUTICS OF COLD BATHS

Now what are the uses of the cold bath in medicine? Its widest application belongs rather to the domain of hygiene. The morning tub is an admirable tonic, always on condition that the reaction of the bather is good. In case the response to the stimulus is feeble or insufficient, a more vigorous reaction may be obtained by causing a warm bath to precede the application of cold. The cold can then be applied as a douche or by rapid sponging. When this plan is adopted, the actual abstraction of heat is very small and may not even amount to what is communicated by the warm water; while the stimulant action of cold—its action in augmenting the internal production of heat—is obtained to the fullest extent. The warmer the bath the colder will a douche of any given lower temperature seem. Water at a temperature of 80° F. to 85° F. would not feel cold in ordinary circumstances; but will appear quite cold after a bath at 98° F. or 100° F. Elderly, feeble, and weakly people, especially those who suffer from cold feet, derive great benefit from cold water applied in this way. A cold bath not followed by sufficient reaction can only be harmful.

In sea bathing the motion of the water has a powerful influence in helping mechanically to excite reaction. The salts in solution work in the same direction.

Local heat-abstracting baths act in the same way; but their action is almost confined to the part dealt with. The general body temperature is unaffected. Tissue change is

retarded during the period of cooling, accelerated during the subsequent reaction. To reduce inflammation, therefore, the application of cold must be continuous.

Cold baths are also much used to lower the temperature in febrile conditions; but as this use lies outside the scope of our work, only the broadest principles will be referred to.

In order to avoid doing harm one or two points must be carefully attended to. The cold should at first be only slightly below the body temperature, and should only gradually be lowered to the desired degree. In this way is avoided the sudden surface chilling which would not merely check the further loss of heat from the skin, but would cause reflexly an increased production of temperature within the body. Another point is that the withdrawal of heat should be stopped as soon as the internal temperature falls. Otherwise dangerous collapse may come on.

## Indifferent Baths

Indifferent baths are those in which the body loses heat at about the same rate as in ordinary circumstances in the air. This temperature is from 34° to 35° C. (93·2° to 95° F.), but varies more or less for different people, and is different also if the water or the bather is in motion.

Such a bath has very little action, except on the nervous system; and here the influence is soothing. This result is accounted for partly by the diminished skin stimuli, and partly by an anæmic condition of the nervous centres. This anæmic condition has been proved by experiment to exist. Schüller found that in an indifferent bath the vessels of the pia mater in trephined animals always contract strongly, and the brain sinks in. The contraction is often preceded for a short time by dilatation of the vessels.

In addition to these sources of diminished nerve activity certain others have been suggested. Nerves, both motor and sensory, have been supposed to become swollen and less

sensitive through absorption of water, and dry and excitable through the removal of water. We may doubt, however, whether the nerves generally can to any large extent be influenced by taking up water in a bath, seeing that absorption through the skin does not occur. But not improbably the nerve endings in the skin may to some extent be influenced in this way.

Indifferent baths are of use in various conditions. Feeble and old people, unable to stand the shock of cold water, may use them with advantage. In hyperæsthesia and subcutaneous inflammations they can also be employed with benefit. In great mental excitement prolonged tepid baths—baths lasting several days—have been used in the treatment of acute mania, especially in continental asylums. The results obtained have as a rule been gratifying.

## Heat-giving Baths

When the temperature of a bath is above the indifferent point—that is, over 35° C. (95° F.)—the loss of heat from the skin is checked under the influence of the warmth; the surface vessels dilate, and a corresponding internal ischæmia takes place. The body temperature rises and the internal production of heat is diminished. In a bath of 99·5° F. (37·5° C.) the internal temperature, according to Liebermeister, rose in 55 minutes from 99·5° to 101·8° F. (37·5° to 38·8° C.). After the bath a compensating fall of temperature occurs. This fall is greater in proportion as the temperature of the bath is high.

The circulation is affected in a marked degree by hot baths, the distribution of the blood throughout the body being much altered. The surface vessels dilate and the skin becomes red and turgid. Corresponding with this outward congestion there occurs an internal anæmia, with diminished activity of the organs within. As a consequence of the diminished blood-supply within and the lessened demand for heat through the nerves, tissue change is diminished.

Less urea is excreted, less carbonic acid given off, and less oxygen taken up; unless the temperature of the body be much raised, and then the excretion of urea and of carbonic acid is increased in amount, and the oxygen taken up is also greater.

The pulse is increased in frequency, and becomes larger and fuller. According to Kisch,[2] baths of a temperature from 35° to 38° C. (95° to 100·4° F.) do not affect sphygmographic tracings as regards frequency, size, or tension. Baths at 39° C. (102·2° F.), lasting twenty minutes, cause arterial dilatation—diminished tension with tendency to dicrotism.

Respiration increases in frequency in warm baths in proportion with the rise of temperature.

Hot baths have a soothing influence on the nervous system. After the bath a tendency to drowsiness is felt. According to Schüller the vessels of the cerebral pia mater contract during a warm bath. This contraction is replaced afterwards by slight expansion. These effects, as well as the opposite effects of cold baths, are probably secondary to the altered calibre of skin vessels.

On the peripheral nerves warm baths—if not very warm—act like baths of indifferent temperature, lowering the excitability of muscles, voluntary and involuntary.

Hot baths, unlike cold baths, render more acute the sense of locality and of touch, sensibility to pain, and the electro-cutaneous sensibility; while the temperature sense, the muscular sense, and the electric excitability of muscle are blunted.

The secretion of the skin is much increased after a warm bath. Even after rubbing with a towel a certain amount of moisture is apt to remain in the pores of the skin and soaked into the epithelium. The evaporation of water remaining in the meshes of the skin causes much loss of heat after a warm bath. If we desire to cause a considerable further removal of heat the drying should be done incompletely. In pyrexial conditions, for example, the temperature may be lowered a good deal in this way. If, on

the contrary, we wish not to allow any loss of heat—the soothing influence of the bath on the nervous system only being looked for—hot towels should be used to dry the skin. By this means the remaining moisture is rapidly evaporated.

Whether the urine is increased in amount after a warm bath is by no means a settled question. The truth probably is that baths only a little above the indifferent point do slightly increase the secretion of urine for a short time after the bath, while baths of a higher temperature—say from 98° to 104° F.—cause a diminished flow. In any case the quantity passed in the twenty-four hours is not materially affected.

The action of baths on the kidneys has been explained in various ways. The current view ascribes the influence partly to reflex action and still more to altered arterial tension.

For a long time the view was held that the reaction of the urine became less acid or even alkaline after warm baths. Later researches have failed to confirm this statement, or the similar one concerning cold baths; and the presence of gases or of mineral substances does not in any way influence the result.

### Therapeutics of Warm Baths

Warm baths have many uses in medicine. The indications can be readily inferred from the physiological action, and may be summed up in a few words. Warm baths are of much value in securing perspiration when the skin is dry and harsh. This application of warm water is often turned to account in the treatment of cutaneous ailments. In the early stage of a "chill" a hot bath often diminishes internal congestion and may ward off a threatened inflammation. The stimulant effect of warm baths in promoting the absorption of exudations causes the thermal treatment of

gout, rheumatism, and chronic inflammatory affections of joints to be much in fashion. At most hot springs, as well as in hydropathic establishments, such cases form a large proportion of the clinical material. In many instances massage aids in attaining the wished-for results.

One of the most familiar uses of the warm bath is to relieve muscular spasms. Severe colic, whether of the bowels, of the gall passages, or of the urinary organs, is usually much alleviated or entirely removed by a hot bath. Dysmenorrhœa also is sometimes relieved in the same way. Hot fomentations or local hot baths belong to the favourite remedies of domestic medicine, and in many of the cases mentioned are as efficient as the hot bath.

In dropsy, consequent on Bright's disease, baths from 38° to 39° C. (100·4° to 102·2° F.) with subsequent packing are recommended by Leibermeister.

An important caution in the use of hot baths has to be borne in mind. In acute nephritis and in dropsy following scarlet fever a hot bath is often useful, but it requires close supervision. In such a case there may be a removal of fluid from the body without any removal of the excrementitious matters that accumulate in the blood. Thus the amount of toxic substances in the blood would remain relatively greater. When the warm bath has a diuretic action its good effect is unquestionable.

Hot baths in the management of local effusions, pleural and peritoneal, for example, are praised by some authors; but other lines of treatment will generally be found more efficacious.

A form for ordering baths is given by Kisch, and is reproduced here:—

Duration of bath
Temperature of bath beginning at
To rise (fall).........degree......every.........minutes.
Final temperature.........
To be followed by massage (douche of temperature.........) drying with hot (cold) towels (incomplete drying).

### Local Hot Baths

Local hot baths act as derivatives from the internal organs, but affect the general system only slightly.

### Vapour Baths, Sand Baths, and other Forms of Baths

In most bathing establishments various baths besides those mentioned are in use. The vapour bath and the Turkish bath are well known. Mud and peat baths are in use in many places. The sand bath has not obtained any great degree of popularity. A few words will indicate the main features of these procedures.

The vapour bath ranges in temperature from 99·5° to 122° F. (37·5° to 50° C.) or even 133° F. (56·1° C.). It may be obtained in various ways: by evaporating water over a spirit lamp, by sprinkling water on a red hot brick, or by a steam kettle, the patient being covered with blankets.

The body temperature is raised in a marked degree in a vapour bath. In a bath with a temperature of about 105·8° to 107·6° F. (41° to 42° C.) the body temperature rises on an average about 2·2° to 2·7° F. (1·2° to 1·5° C.). In a vapour bath of 53° C. (127·4° F.) Bartels saw the rectum temperature rise in 10 minutes from 38° to 40·4° C. (100·4° to 104·7° F.) and in 30 minutes to 41·6° C. (107° F.).

The pulse and respiration are much increased in frequency in vapour baths. At the outset a sense of heat, of bursting, and of oppression of breathing is felt. Gradually the feeling of oppression passes off, and respiration becomes deeper and more frequent than normal.

At first hyperæmia of internal organs takes place. A sense of fulness and giddiness in the head with a sense of pressure against the eyeball is felt. As the skin becomes red the evidence of internal hyperæmia disappears.

In Manassein's Klinik in St. Petersburg a loss of weight, varying from 100 grammes to 900 grammes, was observed

during vapour baths lasting from half an hour to two hours.

In the Turkish bath hot dry air is followed by massage and scrubbing with soap, and then by the application of cold water.

Vapour baths render special service in chronic rheumatic conditions. Local vapour baths, especially when combined with massage, are most effectual in causing the disappearance of chronic inflammatory thickening and stiffness about joints. Within recent years baths of hot dry air and baths of radiant heat have grown in favour.

Arterial degeneration is to be regarded as a special contra-indication to the employment of vapour baths, and as a signal for reserve in the use of baths generally.

### Mud and Peat Baths

Mud and peat baths are in common use in many continental countries. Mud baths (Schlammbäder) consist chiefly of inorganic substances, of which silicic acid is the predominant constituent. Some organic matter, too, varying in amount in different places, is always present. Peat baths (Moorbäder) consist mostly of organic matter with some inorganic matter as well. The essential point both in mud and in peat baths is that innumerable fine hard substances are present whether in the form of sand, fragments of shells, or the hardened remains of plants and trees.

In physiological action mud and peat baths differ from simple hot water baths mainly in the greater stimulation of the skin by the prickly points of the solid contents. Another feature of these baths is that peat and mud being poorer conductors of heat than is water, both higher and lower temperatures can be borne without discomfort.

The mode of using these baths differs more or less in different places. The mud is variously employed as a sort of local hot poultice, as a local or general pack, and as an

ordinary bath. In many places it is customary to heighten the effect by vigorous friction or massage during the bath. Water baths and douches of various temperatures according to circumstances finish the process.

In therapeutic application these baths are practically the same as simple hot baths.

The special characteristic of the sand bath is that the heat is dry, and that no obstacle is thrown in the way of free evaporation. The heat in a bath of this kind is usually about 118° to 122° F. (47·7° to 50° C.) and seldom exceeds 125·6° F. (52° C.), except when applied locally, and then may reach as much as 133° F. (56·1° C.). The duration of a sand bath is about 40 to 45 minutes for a full bath, 45 to 60 minutes for a half bath, and from 60 to 90 minutes for a local bath.

The skin is powerfully excited by a sand bath, and the internal body temperature rises by from 0·9° to 4·5° F. (0·5° to 2·5° C.).

The sand bath is employed in the same kind of cases as is the vapour bath. Chronic inflammatory exudations, rheumatic conditions, muscular contractions, and stiffness of joints are special indications.

The electrical action of baths has been made much of by some writers; but there is not a particle of scientific evidence to warrant the belief in any greater electrical action in the mineral baths at spas than in baths taken quietly in one's own room. The radio-activity of mineral waters now occupies much attention; but up to the present we have only speculations as to its therapeutic influence.

Another antiquated notion is that the solid constituents of the baths are absorbed through the skin. The evidence is now overwhelming that through the unbroken skin there is no absorption except for gases, volatile substances, and substances incorporated with some fatty agent which can be rubbed in. Iron, even if present in tenfold the amount found in mineral water, would, when applied externally, be quite incapable of acting on the blood.

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# CHAPTER XXIV

## MINERAL WATERS TAKEN INTERNALLY

WHAT is the action of water taken internally?

The body may be regarded as a machine for the production of energy in two forms—heat and work. Hot water, in so far as it supplies heat already developed, enables the heat and work producing mechanism to yield a supply beyond what would be possible if the water had to be heated in the system. This fact has important therapeutic applications where the vital powers run low, where the machinery can hardly make good the inevitable loss of heat on the part of the organism. The reviving effect of the ingestion of a hot liquid in depressed conditions is very striking.

Water may be regarded as food. A certain amount of it is indispensable to the life of the tissues. It forms from 59 to 68 per cent of our body, and from 53 to 76 per cent of raw beef. Apart from its action as a food, water can be turned to account as a therapeutic agent. After a draught of cold water the temperature of the body is lowered. According to Winternitz, after a draught of 500 ccm. of water at a temperature of 46·4° F. (8° C.), the temperature in the rectum fell about 1·89° F. (1·05° C.) in 35 minutes. In the axilla the fall was only 0·4° F. (0·22° C.); and this lasted about an hour and a quarter. Lichtenfells and Fröhlich found that drinking 0·3 litre of water at from 64·4° to 61·3° F. (18° to 16·3° C.) lowered the temperature by 0·18° to 0·81° F. (0·1° C. to 0·45° C.) within six or seven minutes.

A draught of cold water lowers the frequency of the pulse and raises the arterial tension. When the quantity of water is large and the cold great, the fall may be between 20 and 30 beats.

Glax [1] gives a remarkably interesting series of pulse and respiration tracings, showing the influence of draughts of cold water—250 ccm. of water at 6° C. (about $8\frac{3}{4}$ ounces at 42°·8 F.) taken at intervals of from 5 to 8 minutes. Within 30 seconds the pulse-rate fell from 80 to 63. After some minutes a rise in the arterial tension was noticeable. After each succeeding draught of water there was a further fall in the pulse-rate with a further rise in tension. When 1250 ccm. in all had been taken the pulse fell to 51. Respiration was not affected to any marked degree; but after 1250 ccm. had been taken it became temporarily quieter.

Another series of pulse tracings by Glax and Klemensiewics [2] shows the influence of hot water drinking. The subject was a diabetic patient 32 years old, who drank daily 1000 cubic centimetres of water at 56°-60° C. (132·8°-140° F.). The tracings were taken before and after the drinking of the morning portion of 500 ccm. during a month. They show that after the draught of hot water the pulse was quicker, but with lower tension; that respiration was also more frequent immediately after the drinking; and that with systematically continued hot water drinking permanent relaxation of the arterial wall was obtained.

Winternitz had previously observed that a draught of 300 ccm. of water at 32·5° C. (90·5° F.) lowered arterial tension; but Kisch found that immediately after 300 ccm. of water at 46° C. (114·8° F.) the arterial tension was raised to a much greater extent than by cold water. His observations are, however, criticised by Glax.

The action of hot and of cold water on the pulse and on arterial tension is well marked before the water could possibly be absorbed. It is therefore probably reflex through the gastric filaments of the pneumogastric nerve.

Water taken into the stomach does not remain there long. But its absorption takes place only to a small amount in that organ, most of it passing through the pylorus. In a man water appeared at a fistulous opening in the duodenum half a minute after being drunk. In a horse it appeared in the cæcum six minutes after being swallowed. Both hot and cold water in moderate quantities appear to excite the peristaltic action of the stomach; but hot water passes on more quickly. Cold water in large quantity arrests the movements of the stomach. Both hot and cold water excite the secretion of gastric juice, but cold water is more active in this respect. Peristalsis of the bowels is also promoted especially by cold water.

Much controversy has taken place as to whether the blood becomes thinner by overmuch water drinking. Schultz found that after heavy water drinking the water in the blood was increased by about 5·7 per cent. Leichtenstern made many observations with the spectroscope on the quantity of hæmoglobin in the blood, but was unable to detect any increase of water even after large draughts of it. The subject of his experiment drank seven litres of water daily, and the blood was examined at the most different periods after it had been taken. The more recent observers agree that copious water drinking temporarily increases the water in the blood.

As water runs so freely through the system, it can evidently be turned to account for cleansing purposes. Waste products can be swept away, and the organism can thus be cleared of various poisonous elements that arise from metabolism of tissue. The quantity of urine passed becomes much greater when cold water in large amount is taken. The quantity of solid substances also is at first increased, though the relative quantity of these is less. The urea is temporarily increased, and this is the case also with chloride of sodium, the phosphates, and the sulphates. According to some observers the uric acid becomes lessened in amount. The ingestion of hot water,

according to Glax, caused only a temporary increase in the flow of urine, but when steadily employed for some time leads to diminished excretion of urine with a simultaneous increase of perspiration.

The increase in the quantity of urea has been considered by many to prove that tissue change is augmented by abundant water drinking. The increase, however, is temporary, and seems to be due to the more complete washing out of the urea that happens to be present. According to the observations of von Noorden,[3] the quantity of water ingested is without influence on nitrogenous tissue change, or on the formation of uric acid or of urea. Whether the oxidation of fat—fat tissue-change—is promoted or retarded by free water drinking is still an unsettled question. Oertel held that in the treatment of obesity the ingestion of liquids should be cut down to the lowest point compatible with the needs of the body. Von Noorden[4] says, "As to the correctness of the observation that the withdrawal of fluids leads to the disappearance of fat there can hardly be a doubt," but he mentions that some animals can be more readily fattened when they receive only a little water. Amongst clinicians Glax upholds Oertel's plan, and limits the amount of liquids, which, he says, in such cases have usually been taken to excess.

The urine is not the only secretion that becomes more copious in proportion to the quantity of water ingested. All the secretions, in fact, become more plentiful: the bile flows more freely—though when water is injected direct into the circulation, this, according to Stadelmann, is not necessarily the case—the solid constituents being also raised in amount, though to a less extent; the pancreatic juice becomes more abundant; the secretion of the parotid is increased; perspiration, sensible and insensible, is augmented. The depurative effect of water, therefore, is of no mean importance; and the general statement may be made that the majority of the mineral constituents of springs are of value in so far as they aid the action of water in this respect either by enabling larger quantities to

be taken with impunity than could otherwise be taken, as in the case of aerated waters, or by securing the same result with a smaller dose, as in the case of the saline or aperient waters, or again by introducing some substance which chemically facilitates the removal of a noxious agent from the body, as when alkaline waters are given to neutralise acids or to clear out the mucus that adheres to the coats of a catarrhal stomach.

### Therapeutics of Water Drinking

The therapeutic uses of water drinking are easily understood from the foregoing physiological account. They may be summarised in general form. Water may be used internally—

(1) To influence arterial tension, pulse-rate, and body temperature. The valuable observations of Glax as to the influence of hot water drinking in lowering arterial tension suggest various therapeutic applications. The anti-diuretic effect of hot water, according to Glax, finds useful employment in diabetes.

In fevers there appears to be retention of water in the system; and for this reason copious drinking of cold water does not tend to lower the temperature, but indeed rather to raise it.

(2) To wash out the tissues or remove impurities, as for example in gout, rheumatism, metallic poisoning.

(3) To alter the activity of unstriped muscular fibres: cold and very hot water exciting to contraction the involuntary muscular fibres of stomach and intestine; warm or moderately hot water having, on the contrary, a soothing action.

(4) To stimulate the secretion of the various digestive fluids: saliva, gastric juice (acid and pepsine), bile, pancreatic juice, succus entericus.

When water is taken for any of these purposes a few points in regard to time, quantity, and mode of administra-

tion have to be borne in mind. In large quantity for therapeutic objects hot water is generally better borne than cold unless fever is present; and then cold water or ice sucked is more agreeable to the patient, and at the same time tends in some instances to lower temperature.

Hot water taken in large amount is of striking benefit in chronic rheumatic and gouty conditions. Symptoms that for a long time had only been kept in abeyance by the almost continuous use of salicylate of soda, have quite disappeared under the influence of hot water taken to the extent of a couple of tumblerfuls night and morning, or even three or four times daily. For most therapeutic purposes the water is best taken on an empty stomach an hour or so before food. It should be sipped slowly, not gulped down. It is removed from the stomach and absorbed before the next meal.

One method of treating obesity is by a lean meat diet and copious hot water drinking; and in the case of robust active men with sound circulation and kidneys it commonly answers well.

In the treatment of certain functional disorders of the stomach, including loss of tone of its muscular fibres, hot water properly used is a most valuable remedy. A very small quantity of hot water taken with meals is a stimulant to digestion. Where this object is in view the amount of hot water should be small—one to three ounces only in the course of the meal. In hyperacidity of the stomach, whether from excessive secretion or from fermentation, a large draught of hot water from two to four hours after a meal will diminish the acidity and stimulate the stomach to propel its contents onwards. But in this case the hot water is much more efficacious with the addition of a little bicarbonate of soda (15 to 30 grains). Apart from washing out the stomach regularly, hot water is perhaps the most useful agent for securing the contraction of a dilated stomach. The success of the treatment, of course, requires the avoidance of the causes that in the first instance led to the dilatation. The temperature of the water should be about

112° to 115° F. Only small quantities should be taken at a time, the object being to stimulate the muscular fibres to contraction, not to introduce such a weight of liquid as might overstrain the weakened muscles. By such means the dilated organ manages to empty itself of fermenting contents and to secure rest before the next meal comes on. For washing out the stomach the water should be lukewarm, or tepid.

Tepid water drunk quickly and in large quantity to excite vomiting will usually cut short the symptoms due to a stomach full of fermenting and indigestible substances.

A tendency to constipation is often relieved by more abundant water drinking. For this purpose the usual plan is to take a tumblerful of cold water at bedtime or, better still, on rising in the morning.

Irritable conditions of the kidney, bladder, and urethra are to a large extent relieved by the more copious ingestion of water, whereby the urine is diluted. Concretions are at the same time gradually dissolved and swept away.

Classifications of mineral waters have been very numerous, and have mostly proceeded on a chemical basis. The classification here offered proceeds on a therapeutic basis.

## MINERAL WATERS FOR INTERNAL USE

### Group A. Depurative

I. *Abluent*—
- (1) Simple thermal waters.
- (2) Sulphur waters.

II. *Stomachic and Diuretic*—
- (1) Simple aerated or table waters, called also acidulated waters, containing free $CO_2$.
- (2) Simple alkaline waters, containing at least 1 gramme of bicarbonate of soda in a litre of water (*i.e.*, 15 grains in 35 ounces, or nearly 9 grains in a pint).
- (3) Alkaline salt waters, containing the chloride as well as the bicarbonate of sodium.

III. *Mild Intestinal Stimulants*—
- (1) Salt waters, of which the chief ingredient is common salt or chloride of sodium. They are divided into simple salt

waters and carbonated salt waters, according to the absence or presence of carbonic acid.

(2) Alkaline aperient waters, of which the chief ingredient is Glauber's salt or sodium sulphate.

IV. *Strong Aperients*—

Of which the chief ingredient is Epsom salts or magnesium sulphate.

### Group B. Tonic and Reconstituent

I. *Hæmatogenic*—

(1) Of which the most important ingredient is iron.

(2) Of which the most important ingredient is lime.

II. *Alterative and Nervine*—

(1) Of which the most important ingredient is arsenic.

(2) Of which the most important ingredient is chloride of barium.

*Lithia* occurs frequently in alkaline waters; *iodine* and *bromine* occur in saline waters. None of these substances, however, is present in sufficient quantity to modify in any important degree the therapeutic action of the water.

### REFERENCES

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2. *Op. cit.* p. 19.
3. C. von Noorden, *Lehrbuch der Pathologie des Stoffwechsels*, Berlin, 1893, pp. 142-143.
4. *Op. cit.* p. 141.

# CHAPTER XXV

## MINERAL WATERS FOR INTERNAL USE

### Group A. Depurative

#### *I. Abluent—Simple Thermal Waters*

These waters are known also as Indifferent Thermals, Akratothermals, and Wildbäder. They are characterised by their heat as they issue from the ground, and by the small amount of their solid constituents; but there is no fixed limit either for their temperature or for the amount of salts they contain. Some members of the group register only 19° C. (66·2° F.); others as much as 70° C. (158° F.). In order to rank amongst the indifferent thermals, a water should contain not more than 0·6 gramme of mineral substance per litre (or 42 grains per gallon). Yet, by some writers, Baden-Baden, which contains 3·8 per thousand; Bath, which contains 2 per thousand; Leuk, which contains 1·67 per thousand; and Wiesbaden, which contains 8·2 per thousand, are all placed in the same class.

The most widely recognised character of these waters is softness, due chiefly to the presence of bicarbonate of soda, instead of the carbonate of lime found in ordinary spring water, rendering it hard. This characteristic should be sufficient to exclude Bath and Leuk from ever being classified amongst the simple thermal springs.

These waters are bright and transparent, and, seen in mass, have a bluish tinge. Though soft, they have a pleasant taste unlike the insipid taste of ordinary warm

water. They contain only a small amount of gas, which consists of carbonic acid, oxygen, and nitrogen in various proportions.

Nearly all the simple thermal springs that have become popular as resorts owe something to a picturesque situation, a beautiful, well-wooded country, or a fine, bracing climate. The restfulness, the freedom from the daily worries of active professional or business life, the beauty of the surroundings, the regular out-door life, are powerful aids in securing the restoration of health. These influences "grow upon" the visitor, and tend to make him return to the same place year after year.

Many of the simple warm springs are used chiefly for baths, and but little or not at all for drinking cures. The therapeutic indications of these waters are practically the same as those that have been laid down in reference to plain warm water. In the form of baths they are useful in rheumatic and gouty ailments, stiffness of muscles or of joints, whether from injury or from disease.

They are in great favour with people getting on in years, and are sometimes spoken of as "old people's baths." Hufeland,[1] speaking of Schlangenbad, says: "I know of no bath so well fitted as this to preserve the character of youth and to postpone old age. From experience I know that the regular annual use of this bath begun in good time is able to maintain cheerfulness of spirit, suppleness of limb, and strength to old age."

The warm baths of the simple thermal spas have found favour also in the treatment of chronic exudations in the neighbourhood of the pelvic viscera as well as in cases of old thickening around joints. Massage, regulated movements, controlled either by a bath attendant or by mechanical appliances, form an important feature of the treatment as carried out at several of the indifferent thermals; and these measures commonly share with the baths the credit for the success of the treatment. At these baths all the resources of hydrotherapeutics are well understood; and a variety of effects can be produced according to the mode of

applying the water, whether by bath or by jet, douche, or shower, according to its duration and temperature, according as a uniform temperature is maintained, or a hot shower is followed by a cold one, and so on.

In some chronic abdominal disorders—sluggish action of liver and intestines for example—benefit is, as a rule, obtained from the treatment adopted at these springs, including massage and regulated movements. In such cases, however, the chloride of sodium or sulphate of sodium waters are usually preferred.

Among skin diseases, acne, prurigo, pruritus, and urticaria are those for which relief is most commonly sought at the indifferent thermals. Some cases of psoriasis and of chronic dry eczema also receive benefit. But most skin diseases can be treated quite as satisfactorily by the ordinary remedies at the patient's own home.

*Internal Use.*—In most of the ailments for which the waters are used externally, their internal use is attended with benefit. This is especially the case in gouty and rheumatic states.

In the treatment of recent bronchial catarrh of irritable character and attended with little secretion, the indifferent thermal springs, like most other mineral waters, are capable of affording much relief, particularly when inhaled as a fine, warm spray. The same procedure does much to alleviate laryngeal and pharyngeal catarrh as well as paroxysms of spasmodic cough.

In catarrhal and spasmodic conditions of the urinary apparatus the simple thermal waters taken in large quantity relieve irritation, help to dissolve concretions, and wash out the passages.

"Chronic metallic poisoning," whether by lead or by mercury, is a standing dish amongst the indications for all mineral springs, including the simple thermal spas. For this class of case the sulphur waters have, as a rule, the preference; but the indifferent thermals do not lack supporters.

A list of the most important of these springs with their leading characteristics follows :—

### England

Buxton, Derbyshire. Altitude, 1000 feet. Climate, bracing. Temp. of water, 82° F. In addition to the simple thermal water there is a so-called chalybeate spring, which contains about one grain of carbonate of iron to the gallon. Radium also has been found in the Buxton springs. Indications *: gouty and rheumatic ailments and stiffness of joints. Season : May to September ; but open all the year round.

Matlock, Derbyshire. Climate, mild. Temp. of water, 68° F. Hydropathic establishments. Indications : gouty and rheumatic affections ; neurasthenia and nervous irritability.

The springs of Bath are sometimes regarded as indifferent thermals ; but are more properly classified amongst the Earthy Waters (page 411).

### France

Plombières. Altitude, 1470 feet. Climate bracing but changeable. Temp. of water, 54°-156° F. Indications : dyspepsia, gastralgia, chronic diarrhœa ; rheumatic and uterine affections. Season : May 15 to October 15.

Luxeuil-les-Bains. Altitude, 980 feet. Indications and season same as for Plombières.

Evian-les Bains. Altitude, 1230 feet. Temp. of water, 53° F. On slopes on south side of Lake of Geneva. Faces north. Climate mild. Indications : urinary ailments, gravel, catarrh of bladder ; gastric and intestinal catarrh ; gout, uterine ailments, neurasthenia. Season : May 1 to October 15.

Bains, Vosges. Altitude, 1000 feet. Temp. of water, 90°-122° F. Climate, variable. Indications : rheumatism, neurasthenia, uterine ailments with nervous complications, dyspepsia. Season : May 15 to September 15.

Aix-en-Provence (Bouches du Rhône). Altitude, 590 feet. Temp. of water, 68°-97° F. About 17 miles from Marseilles. Indications : neurasthenia, rheumatism, sciatica, stiffness of joints. Skin and uterine affections.

Dax. Altitude, 130 feet. Temp. of water, 140° F. Indications : rheumatic affections, especially in scrofulous and lymphatic subjects ; sciatica, old wounds, dry skin diseases, uterine catarrhs and pelvic exudations. Season : Whole year round, but especially spring and autumn.

Néris. Altitude, 1161 feet. Temp. of water, 120°-127° F. Climate mild ; rather hot in summer. Indications : nervous ailments,

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* The indications throughout this table are those established by custom.

especially of a painful or irritative character; neurasthenia, hysteria, and chorea; gout, rheumatism; subacute and chronic uterine ailments with nervous symptoms; skin diseases. Season: May 1 to September 30.

Ussat. Altitude, 1430 feet. Temp. of water, 87°-105° F. Indications: rheumatic, nervous, and uterine ailments.

### Switzerland

Ragatz-Pfäfers. Ragatz altitude, 1700 feet; Pfäfers about 3 miles away in beautiful gorge, altitude, 2250 feet. Temp. of water, 99° F. Climate sedative. Indications: irritable and painful nervous affections, neurasthenia; gout, rheumatism; bladder troubles; uterine ailments. Season: June 1 to September 30; but open from April or May to October.

### Germany

Badenweiler, Black Forest. Altitude, 1380 feet. Climate mild. Temp. of water, 80° F. Indications: irritable state of nerves and of respiratory passages; laryngeal and pharyngeal catarrh. Season: May 1 to September 30.

Wildbad, Wurtemberg, Black Forest. Altitude, 1400 feet. Temp. of water, 98° F. Indications: old age; overwork; nervous affections, paralytic trouble, especially hemiplegia; rheumatism. Season: May 1 to September 30.

Schlangenbad, Hesse-Nassau, Prussia. Altitude, 1020 feet. Climate bracing. Temp. of water, 82°-90° F. Indications: nervous irritability; female complaints. Season: May 1 to September 30.

### Austria

Teplitz, Bohemia. Altitude, 750 feet. Climate mild. Temp. of water, 82°-120 F. Indications: rheumatism; nervous ailments; old wounds; stiff joints. Season: May 1 to September 30.

### Italy

Bormio, Province of Valteline, 7 hours by diligence from Sondrio. Sondrio is the terminus of a railway line from Colico on the lake of Como. Altitude, 4700 feet. Temp. of water, 105° F. Indications: skin disease; gout, rheumatism; female complaints; hysteria.

### REFERENCE

1. Quoted by Baumann in Valentiner's *Handbuch der allgemeinen und speciellen Balneotherapie*, Berlin, 1873, p. 641.

# CHAPTER XXVI

## MINERAL WATERS FOR INTERNAL USE

### Group A. Depurative

### *I. Abluent* (continued)—*Sulphur Waters*

Until lately sulphur waters have been held in the highest repute. The strong odour, though due to an infinitesimal quantity of sulphuretted hydrogen, could not fail to attract attention. The virtues commonly ascribed to sulphur were transferred without question to waters seemingly so richly impregnated with that substance.

Since chemical analysis has shown that only an infinitesimal quantity of sulphur is present in even the strongest sulphur waters, and since a precise and critical spirit has replaced the vague and exaggerated views of former times, sulphur waters have fallen from their high pedestal to take their proper rank amongst indifferent waters.

The same causes, however, which have led to the abasement of the sulphur waters have raised the dignity of the indifferent thermals. The cleansing and depurative influence of pure water in baths and in large doses internally is now more fully recognised than formerly. To this cleansing and depurative influence justly belong the merits ascribed in ignorance to sulphur or its compounds.

Indications are not wanting to show that the indifferent thermals may soon hold the highest place of honour amongst mineral waters. Evidence was brought forward a few years ago by Sir William Roberts, in his "Croonian Lectures," to

show that in gout and allied diseases, where one of the main features is accumulation of uric acid in the blood and tissues, the sodic or saline waters are less efficient solvents than is plain water. As these diseases form a large proportion of the staple material at most drinking spas, the view in question would greatly change the relative esteem in which various waters are held.

Although sulphur waters may have merely the virtues of indifferent waters, tradition and custom have assigned special qualities to them, and have selected certain classes of ailments as particularly likely to be benefited by particular springs. As a consequence of this special reputation of various waters of essentially the same therapeutic value, a large number of purely arbitrary distinctions must be borne in mind by the practitioner who wishes to avoid, for example, sending to Saint-Sauveur, which is essentially a ladies' bath, a case suitable for Aix-la-Chapelle, which is chiefly given over to the treatment of syphilis in men. Even though the waters may be efficacious and the bath physician competent, the patient is not likely to be impressed with the correctness of the selection, and, if he regains his health at all, will do so in doubt, not with faith.

Sulphur waters have been divided according as they are warm or cold, and further subdivided according as they contain sulphuretted hydrogen, sulphide of sodium, or sulphide of calcium. The amount of sulphuretted hydrogen varies from a mere trace to about 42·6 ccm. in a litre of water, as in Herculesbad at Mehadia in Hungary. These figures are roughly equivalent to 3 cubic inches to the quart. The amount of sulphide of sodium or of calcium in these waters ranges from the merest traces to 7 centigrammes per litre, or less than a grain and a half to the quart. The sulphides are unstable salts, and when the water containing them is exposed to the air they are decomposed, sulphuretted hydrogen being formed, which in turn is broken up, the sulphur being precipitated and the hydrogen uniting with oxygen.

A nitrogenous substance found in sulphur waters has

given rise to a good deal of discussion. It has been named variously, according to its physical characters and its place of origin—glairine, géline, sulphurose, sulphydrine, barégine, pyrénéine, luchonine, axine, saint-sauverine. This substance consists of various low forms of animal and vegetable life and of the dead matter arising therefrom. The living matter, consisting chiefly of *algæ* and *confervæ*, is known under the generic designation of *Sulphurairia*[1] in which are found different varieties of *Ulothrix*, *Oscillaria*, and especially *Beggiatoa*. The living organisms and the dead matter alike reduce the alkali sulphates into sulphides by taking up oxygen. The living matter further takes up some of the sulphur. From this matter when undergoing decay, and from the alkali sulphides formed by its agency, the sulphur waters receive the sulphuretted hydrogen, on which is based their claim to glory.

Carbonic oxysulphide, discovered by von Than in 1867 in Harkány waters, is of interest only to the chemist.

As to the physiological action of sulphur waters, facts are scanty, and theory proportionately abundant.

A few points are generally attested. Sulphur waters taken internally cause a tendency to constipation. The stools become dark and by degrees black. An anæmic condition is said to follow the prolonged use of these waters. It is stated that the flow of bile is promoted and that enlargements of the liver subside under their influence. Whether the action on the blood, on the bile, and on the liver is greater than in the case of pure water is a matter of assertion rather than of proof.

The physiological action of these waters is, in fact, usually inferred *a priori* from the physiological action of sulphuretted hydrogen. Sulphuretted hydrogen is a poison of the most active type, though, in a general way, it acts most virulently on small animals and the less highly organised beings. According to Thénard and Dupuytren $\frac{1}{1500}$ per cent in the air will in a short time kill a bird; $\frac{1}{800}$ per cent proves fatal to a dog of medium size; $\frac{1}{250}$ per cent is required to kill a horse; while man is

comparatively slightly sensitive to its toxic effects, being able to breathe without ill consequences an atmosphere charged with 1 per cent, and for a short time even as much as 3 per cent. It can be absorbed through the skin, lungs, and digestive tract in quantities large enough to prove rapidly fatal. The symptoms of poisoning are faintness, giddiness, trembling, and sometimes convulsions. It is supposed that the very small doses of $H_2S$ present in sulphur waters cause symptoms the same in kind as those from poisonous doses, but infinitely less in degree. The quantities, however, are too small even to give support to this view. The mode of death in poisoning by sulphuretted hydrogen is usually said to be by the deoxydation of the blood, the gas uniting with the iron of the hæmoglobin, thus destroying its oxygen-carrying power. When blood is exposed to the gas in a test tube the reducing action is strongly marked; but an experiment by C. Bernard shows that the explanation is inadequate when the blood is in the vessels of the animal. Bernard introduced sulphuretted hydrogen in large quantity, but slowly, into the venous system of a dog without causing any noteworthy symptoms in the animal. This could not be the case if Liebig's view were correct that the gas unites directly with the iron of the corpuscles. When the gas, however, was introduced into the arterial system it proved rapidly fatal; probably by a direct toxic action on the nervous centres, which in the other experiment it never reached, being eliminated as soon as it arrived in the lungs.

Experience has shown the usefulness of the sulphur waters in certain forms of disease, though it has not proved any superiority over the simple thermal or indifferent springs in the same field. The therapeutic employment of the sulphur waters extends over a wide series of ailments. These ailments are much the same for all wells of the group, in spite of a certain specialisation of some springs for particular diseases.

Rheumatic and gouty affections are those for which these baths as a class are most celebrated. At every resort of the

kind, especially at the hot sulphur springs, sufferers from these ailments form a large proportion of the visitors. As a rule only such cases are suitable as show no tendency to an acute outburst of the disease, though in Aix-les-Bains stress is not laid on this point; and the time of the subsidence of an acute attack of gout is regarded by some as the best moment to begin treatment there.

Chronic pharyngeal catarrh is another ailment in the treatment of which all the sulphur waters are more or less popular. The same may be said of laryngeal and bronchial catarrhs, especially those with irritable cough and scanty secretion. The improvement that undoubtedly takes place in such ailments from the employment of these waters has led to an extension of their use to cases that would derive greater benefit from a different line of treatment. Allevard, Eaux-Bonnes, and Cauterets claim to be helpful in cases of chronic pulmonary phthisis without fever. This claim, however, can hardly be admitted. A tendency to hæmoptysis is usually regarded as a contra-indication. Weilbach is credited by Braun with good effects in cases of chronic phthisis with cavities where "hæmorrhoidal enlargement of the liver" was present. As a rule, however, tubercular affections of the lungs and air-passages are not suitable for bath treatment.

Asthma is sometimes relieved by sulphur waters as by alkaline saline waters, and indeed by the most various measures, in accordance with its manifold causation.

Syphilitic affections are frequently sent for treatment to sulphur springs, and Aix-la-Chapelle (Aachen) has acquired a unique reputation for its success in dealing with obstinate manifestations of the disease. To the sulphur, however, but a minute portion of the credit is due. Mercurial treatment is effectively carried out by inunction. Aix-les-Bains, though not quite so popular in this line as its German rival, receives a large number of cases of the same kind; as do also the sulphur springs of the Pyrenees.

Skin diseases furnish a large contingent of visitors to sulphur springs. Chronic eczema, psoriasis, and the

various forms of acne are amongst the commonest forms. Since Hebra showed that those forms of skin diseases that are benefited by sulphur require that substance in much larger quantity than any mineral water can boast of, the vogue in this direction has fallen off in the medical world, though popular belief still clings to the old faith. The bath physicians do not, however, as a rule, restrict themselves to their own waters, but, according to the needs of the case, have recourse to other therapeutic measures.

Chronic catarrhal conditions of the digestive tract are treated with success, as elsewhere, at most sulphur springs. Bagnères de Bigorre, Bagnères de Luchon, St. Sauveur, Cauterets, and our own Harrogate, are amongst the favourite sulphur waters used for the purpose. German writers lay stress on the value of these waters where there is a hæmorrhoidal tendency. The sulphur waters, they assert, have a special efficacy on the liver, removing engorgements, and diminishing the size of the organ, increasing the flow of the bile, and cleansing the whole portal system.

In nervous affections the employment of baths and drinking cures is less common than in former days. Amongst the cases most likely to be benefited are paralysis and weakness due to neuritis, whether from alcohol, diphtheria, or other cause; but only after the acute symptoms have passed away. Paralytic conditions due to a former cerebral or spinal hæmorrhage are not likely to benefit more from sulphur waters than from simple thermal baths. Sufferers from locomotor ataxy sometimes think that baths help to ease the severity of their pains.

For uterine affections mineral waters generally are resorted to much more amongst the continental nations than is the case with us. The iron, the alkaline, or the saline springs are, as a rule, preferred in these ailments, the selection depending upon the nature of the case. St. Sauveur and Eaux-Chaudes are supposed to be specially useful in neuralgic pains attending chronic uterine inflammation in lymphatic or gouty cases; and indeed all the other Pyrenean sulphur waters are more or less employed

in uterine troubles, especially those of Bagnères-de-Luchon, Bagnères-de-Bigorre, and Cauterets.

Chronic metallic intoxications, whether from lead or mercury, are supposed to be in a special degree amenable to the influence of sulphur waters. Largely through this supposition, indeed, Aix-la-Chapelle attained its fame in the treatment of syphilis. It was thought that by means of the sulphur water, persons who had hitherto been unable to take mercury acquired a sufficient degree of tolerance. In either of two ways its action might be explained. According to one theory, the mercury circulating as an albuminate in the tissues was converted into a sulphide which formed a soluble compound with the alkali sulphide, and was thus carried out of the system. Or, according to another theory, the mercury was converted into an insoluble sulphide, and so remained harmless in the tissues. There is, however, no proof that sulphur waters, internally or externally, have any more virtue for the purpose than has ordinary waters. As regards lead, the theory was that an insoluble sulphide was formed whereby the metal was removed from the circulation, fixed in the tissue, and thus rendered innocuous.

As to ailments of the urinary apparatus, La Preste has a special reputation for efficacy in gravel and in chronic catarrh of the bladder. St. Sauveur, Barèges, Bagnères de Luchon, and Aix-les-Bains are also employed with success in similar cases.

In the treatment of old bullet wounds, fistulous tracts, and troublesome cicatrices, all the sulphur waters, but especially those of the Pryenees, have a great name. Dr. Macpherson,[2] speaking of the Barèges Springs, says: "No waters are in greater repute for the cure of certain ailments; and at the head of these stand old wounds and cicatrices and chronic diseases of bone—in them it certainly works wonders. I have known them open a cicatrix of twenty years' standing, and dislodge a piece of cloth that was impacted." Tubercular affections of bones and joints can, as a rule, be managed more judiciously without recourse to bath treatment.

| | Name and Temp. (F.) of Spring. | $H_2S$. c.cm. | $Na_2S$. | $CaSO_4$. | Other Constituents. |
|---|---|---|---|---|---|
| | Parts per thousand. | | | | |
| ENGLAND AND WALES | | | | | |
| *Harrogate*, Yorkshire. — Altitude 250-600 feet. Climate bracing. Indications:* gouty and rheumatic ailments, dry skin diseases, liver troubles. Iron waters (*q.v.*) useful in anæmia. Season: May to September, but open all the year round | Old Sulphur Spring 48° | 37 | ... | ... | Sod. chloride 12·7 Barium chloride 0·09 |
| *Llandrindod Wells*, Radnorshire. — Altitude 700 feet. Climate bracing. Possesses also chalybeate spring. Indications same as for Harrogate | Old Sulphuretted Spring 48° | 9·5 | ... | ... | ... |
| SCOTLAND | | | | | |
| *Strathpeffer.*—Climate rather relaxing. Also mild chalybeate spring. Indications: gout and rheumatism, psoriasis, gouty eczema. Season: May to October; but open all the year round | Strong Well | 40 | ... | 0·66 | ... |
| *Moffat.*—Altitude 400 feet. Rainy. Hydropathic establishment; but sulphur water not used there. Also a mild chalybeate spring | ... | 72 | ... | ... | ... |
| IRELAND | | | | | |
| *Lisdoonvarna*, co. Clare. —Open, breezy, but rainy. Also chalybeate water. Indications: chronic gout and rheumatism, dyspepsia, skin diseases. | ... | 4·1 | ... | ... | ... |
| FRANCE | | | | | |
| HAUTES-PYRÉNÉES | | | | | |
| *Barèges.*—Altitude 4050 feet. Climate cold, changeable. Indications: scrofula, deep-seated affections of bones and joints, thickenings from old sprains and fractures, old wounds and fistulæ, scrofulous skin affec- | Tambour 111° | ... | 0·04 | ... | ... |

* The indications throughout this table are those established by custom.

| | Parts per thousand. | | | | |
|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $H_2S$. c.cm. | $Na_2S$. | $CaSO_4$. | Other Constituents. |
| FRANCE—*continued.* tions, syphilis, paralysis of functional, rheumatic, or saturnine origin. Contra-indications: gout, pulmonary tubercle, hæmorrhagic tendency, generally respiratory and nervous ailments where stimulation is to be avoided. Season: June 1 to September 30 | | | | | |
| *Cauterets.* — Altitude 3050 feet. Climate mild, but changeable. Indications: chronic catarrh of respiratory organs. Season: May 15 to October 31 | Raillière 103° | ... | 0·017 | ... | ... |
| *St. Sauveur.*—Altitude 2540 feet. Climate mild. Indications: diseases of women. Season: June 1 to September 30 | 93° | ... | 0·02 | ... | ... |
| *Bagnères-de-Bigorre.* —Altitude 1810 feet. Climate mild, rather humid. Also iron and arsenic springs. Indications: practically every disease. The *Foulon* and *Salut* springs are reputed sedative; the *Reine*, *Dauphin*, and *Saint-Roch* springs very exciting; *Reine* and *Lasserre* aperient. Season: June 15 to October 15 | Labassère (5 miles from Bagnères; water brought over fresh every morning for drinking) | ... | 0·04 | ... | ... |
| BASSES-PYRÉNÉES | | | | | |
| *Eaux-Bonnes.* — Altitude 2460 feet. Climate warm, but changeable. Indications: respiratory catarrhs and torpid forms of pulmonary tubercle. Season: June 1 to September 30 | Source vieille 91°·4 | ... | 0·02 | ... | ... |
| *Faux-Chaudes.* — Altitude 2220 feet. Climate rather windy. Indications: uterine ailments. Season: June 1 to September 30 | Clot 97° | ... | 0·01 | ... | ... |
| PYRÉNÉES-ORIENTALES | | | | | |
| *Amélie-les-Baines.* —Altitude 910 feet. Climate mild, dry, warm; also pleasant in winter. Indications: same as for Bagnères and Luchon. | Grand Escaldadou 141° | ... | 0·01 | ... | ... |

| | Parts per thousand. | | | | |
|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $H_2S$. c.cm. | $Na_2S$. | $CaSO_4$. | Other Constituents. |
| FRANCE—*continued.* Season: May 1 to October 31; but open all the year round | | | | | |
| *Le Vernet.*—Altitude 2040 feet. Climate dry, mild, especially in winter; but the valley is open to the north and exposed to the mistral. Indications: catarrhal states of the respiratory organs. A sanatorium for phthisis under the direction of Dr. Sabourin was established some few years ago on the model of the German establishments at Görbersdorf and Falkenstein. Season: all the year round | 95°-136° | ... | 0·01-0·04 | ... | ... |
| *La Preste.*—Altitude 3670 feet. Climate mild, mountain. Indications: chiefly urinary affections, nephritis, cystitis, gravel, diabetes. Season: May to October; but open all the year | Apollon 111° | ... | 0·01 | ... | ... |
| HAUTE GARONNE | | | | | |
| *Bagnères-de-Luchon.*—Altitude 2070 feet. Climate mild, but changeable. Forty-nine springs. Indications: skin diseases, syphilis, rheumatism, and scrofula in torpid and lymphatic subjects. Season: June 15 to October 15 | La Reine 131° | ... | 0·05 | ... | ... |
| NIÈVRE | | | | | |
| *St. Honoré.*—Altitude 1000 feet. Climate mild, dry. Indications: chiefly respiratory ailments, nasal and pharyngeal catarrhs, laryngitis, pharyngitis, pulmonary tubercle. Season: May 15 to September 30 | Crevasse 79° | 2-7 | ... | ... | Ac. arsen, 0·001 $CO_2$ 111 c.cm. |
| SAVOIE | | | | | |
| *Challes.*—Altitude 890 feet. Climate mild, dry, warm. Indications: scrofula, syphilis, skin diseases, catarrhs of respiratory mucous membranes, rheumatism. Challes water | 55° | ... | 0·36 | ... | Sodium iod. 0·012 |

| | Parts per thousand. | | | | |
|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $H_2S$. c.cm. | $Na_2S$. | $CaSO_4$. | Other Constituents. |
| FRANCE—*continued.* also much used internally at Aix-les-Bains. Season: May 15 to October 15 | | | | | |
| *Aix-les-Bains.* — Altitude 870 feet. Climate mild, hot in summer. Indications: gout, rheumatism, syphilis, skin affections of rheumatic origin. Internally Challes water chiefly used. Season: May to October; but open all year round | Source de soufre 115° | 2·2 | ... | ... | ... |
| ISÈRE | | | | | |
| *Allevard.* — Altitude 1560 feet. Climate dry, rather variable, hot in summer. Indications: respiratory catarrhs, skin diseases, scrofula, rheumatism. Season: June 1 to September 30 | 75° | 24 | ... | ... | ... |
| GERMANY | | | | | |
| RHENISH PRUSSIA | | | | | |
| *Aix-la-Chapelle* (Aachen).—Climate mild; altitude 550 feet. Indications: syphilis, gout, rheumatism, metallic poisoning. Season: May 1 to October 15; but open throughout the winter | Kaiserquelle 131° | ... | 0·01 | ... | Sodium chloride 2·6 Sod. bicarb. 0·9 Silica 0·06 |
| *Burtscheid,* adjoining Aix-la-Chapelle.—Climate, indications, and season the same | Mühlenbad-quelle 167° | ... | 0·001 | ... | ... |
| HESSE NASSAU | | | | | |
| *Weilbach.* — Altitude 450 feet. Climate mild. Indications: respiratory catarrhs. Season: May to October | 55° | 5 | ... | ... | ... |
| *Nenndorf.* — Altitude 230 feet. Also salt baths. Indications: those of sulphur and salt baths generally. Season: May 1 to September 30 | Trinkquelle 54° | 42 | ... | 1·0 | $CO_2$ 187 c.cm. Calcium sulphide 0.07 |
| LIPPE SCHAUMBURG | | | | | |
| *Eilsen.*—Altitude 250 feet. Indications: same as for sulphur waters generally. Sasson: June and August | Julianen-brunnen 54° | 40 | ... | 2·0 | $CO_2$ 0·1 =50 c.cm. |

| | Parts per thousand. | | | | |
|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $H_2S$. c.cm. | $Na_2S$. | $CaSO_4$. | Other Constituents. |
| AUSTRIA | | | | | |
| *Baden*, near Vienna.—Altitude 760 feet. Climate variable. Indications: gout, rheumatism, skin diseases, scrofula. Season: whole year round. Grape cure in autumn. | Römerquelle 93° | Traces | ... | 0·6 | ... |
| HUNGARY | | | | | |
| *Ofen* (Budapesth).—Altitude 330 feet. Indications: chronic skin diseases, gout, syphilis. Season: all the year round | Stadtwäldchen Artesian spring 165° | 0·5 | ... | ... | ... |
| *Mehadia.*—Altitude 550 feet. Climate: mild. Indications: same as for Ofen. Season: summer and winter | Elisabethquelle 129° | 24 | ... | ... | Sodium chloride 3·4 Calcium chloride 2·0 Calcium sulphide 0·047 |
| SWITZERLAND | | | | | |
| CANTON BERNE | | | | | |
| *Lenk.*—Altitude 3640 feet. Climate: protected from wind, warm in summer. Indications: skin diseases, chronic eczema, acne, boils, naso-pharyngeal and bronchial catarrhs, pulmonary phthisis. Also mild chalybeate spring. Season: June 15 to September 30. | Balmquelle 47° | 44·5 | ... | 1·6 | ... |
| *Gurnigel.* — Altitude 3800 feet. Climate: mild, mountain; humidity considerable owing to surrounding forest; changeable. Indications: liver and digestive troubles generally, naso-pharyngeal catarrh, skin diseases. Season: June to September | Schwarzbrünneli 46° | 35 | ... | 1·3 | Nitrogen 24 c.cm. Carbonic acid 401 c.cm. |
| *Heustrich.* — Altitude 2240 feet. Climate: mild, mountain; warm in summer, but variable; humidity high from abundance of timber. Indications: catarrhal affections of the respiratory and of the urinary passages. Season: June 1 to September 30 | Source sulfureuse 41° | 11 | 0·03 | ... | Nitrogen 31 c.cm. |

| | Parts per thousand. | | | | |
|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $H_2S$. c.cm. | $Na_2S$. | $CaSO_4$. | Other Constituents. |
| SWITZERLAND—*continued.* | | | | | |
| CANTON DES GRISONS | | | | | |
| *Alveneu.* — Altitude 3130 feet. Climate: mild, mountain, warm in summer, variable. Indications: gout, rheumatism, neuralgia, gastro-intestinal and respiratory catarrhs. Season: June to September | 46·5° | 0·9 | ... | 0·95 | Carbonic acid 11 c.cm. |
| AARGAU | | | | | |
| *Baden.*—Altitude 1280 feet. Climate: mild, hot in summer. Indications: gouty and rheumatic affections. Season: June to October. Some baths open all year round | Verenahof-quelle 115° | 0·7 | ... | 1·35 | .. |
| *Schinznach.*—Altitude 1130 feet. Climate: mild, warm in summer. Indications: skin diseases, scrofula, syphilis, respiratory catarrhs. Season: May to October | 95° | 37 | ... | 1·0 | Carbonic acid 90 c.cm. |
| ITALY | | | | | |
| PROVINCE ALESSANDRIA | | | | | |
| *Acqui.*—Altitude 540 feet. Climate: moist, variable, hot in summer. Indications: rheumatism, gout, and joint affections generally, skin diseases. Season: May 15 to September 30 | La Bollente 167° | 18 | ... | ... | Iron bi-carbon. 0·08 |
| *Valdieri.* — Altitude 4000 feet. Fifteen miles from Cuneo (by carriage and mules). Climate: cool. Indications: rheumatism and gout. Season: July and August | 147° | ... | ... | ... | ... |

## REFERENCES

1. Art. "Sulfuraires," by Ed. Heckel in *Dict. Encyclopéd. des Sciences médicales.*
2. John Macpherson, *The Baths and Wells of Europe*, 3rd ed. 1888, p. 168.

# CHAPTER XXVII

## MINERAL WATERS FOR INTERNAL USE

### Group A. Depurative

### *II. Stomachic and Diuretic—Simple Aerated or Table Waters*

Simple aerated waters, known also as acidulated, and as carbonated waters, contain from 300 to 1500 volumes of carbonic acid in 1000 volumes of water. The most important solid constituents, as a rule, are bicarbonate of sodium, bicarbonate of lime, chloride of sodium, and sulphate of sodium. Minute quantities of iron are present in some members of the group. A water that holds in solution enough of any substance to have a therapeutic value would be ranged in a corresponding group, no matter how rich in carbonic acid it might be. In this group are placed aerated waters containing not more than 0·03 per thousand of bicarbonate of iron, 1 per thousand of chloride of sodium, of bicarbonate of sodium, lime, or magnesium, the total solids being under 3 per thousand. This principle of classification is, however, not very strictly followed, some waters being included which would lie outside the boundary thus marked out.

These waters are almost all cold. Owing to their pleasant taste they are in great demand as table waters, and for this purpose are largely exported, the water when bottled being in some cases further charged artificially with carbonic acid. Amongst the representatives of this class of waters, Apollinaris, St. Galmier, and Gieshübler are known to all.

The simple aerated waters are used almost entirely for exportation. Only when springs of this kind happen to be in the neighbourhood of more powerful spas are they much used on the spot.

The physiological action of carbonated waters seems to be due almost, if not entirely, to the effect of the gas on the nerve ends of the mucous membranes. In the mouth carbonic acid escaping from the water in fine bubbles causes an agreeable prickling sensation, which is continued more or less during the passage of the water to the stomach. In the stomach there is a feeling of warmth and generally of distension. The organ is stimulated to contraction, expelling the gas more or less completely by the mouth. In some irritable conditions of the bowels general peristaltic action of the whole intestinal tract is set up, but ordinarily the intestines are but slightly, if at all, affected.

The general effect of carbonic acid on the nervous system is sometimes ascribed to absorption of the gas from the digestive tract. A sense of freshness and exhilaration is felt very soon after the aerated drink is taken, the exhilaration sometimes reaching a kind of intoxication. There is, however, no evidence to show that the gas is absorbed in quantity sufficient to produce any physiological effect, or that, if it were absorbed, the symptoms would be of an exhilarating character. An increase of carbonic acid in the blood in fact gives rise to quite the opposite effects. The carbonates in the urine, which stand in close dependence on the proportion in the blood, are not increased by the ingestion of aerated drinks. Absorption could of course take place only in so far as the tension of the gas in the stomach or bowels exceeded the tension in the blood. The sense of freshness and the exhilaration are, however, quite sufficiently accounted for by the reflex excitement of the nerve centres through the stimulation of nerve endings of tongue, palate, and stomach. Snuff-takers experience a somewhat similar clearing of the brain through the titillation of the nerves of the nasal mucous membrane.

Aerated waters are more rapidly absorbed than is plain

water, and hence cause a more rapid flow of urine. That the increase is due not to a direct influence of the carbonic acid, but to more rapid absorption is shown by the fact that when an effervescent powder with a small amount of water is taken, the flow of urine is not increased.

As to whether aerated waters heighten arterial tension, the evidence is conflicting. According to Quincke they are without influence in this direction. Glax,[1] on the contrary, holds that they raise tension, thus increasing the rise of blood pressure due to the drinking of cold water. In favour of his contention he cites the general testimony of physicians practising at highly aerated springs, that hæmorrhages are common after the use of these waters.

Though used chiefly as table drinks, the aerated waters are not without value in therapeutics. In irritable conditions of the stomach they often render milk or alcohol tolerable to the patient. A little carbonic acid in a water, by its local stimulant effect, gives a slight fillip to the appetite, and by causing better mixing of the food and more active movements of the muscular coat aids digestion. Alcohol acts much more speedily in drinks containing carbonic acid than in any other form.

There is one important contra-indication for aerated drinks in stomach troubles. In dilatation of the organ its flabby walls, instead of being provoked to expel the gas, may simply yield to the pressure, and thus the original evil becomes aggravated. Dilatation of the stomach is always accompanied by flatulence, and in such cases the discomfort to the heart is increased by the further distension and consequent pressure on the neighbouring organs.

Carbonated waters used as baths cause a pleasant prickling sensation with a feeling of warmth. They are stimulant to the skin, and have a soothing action on the nervous system. They are useful in pruritus and prurigo, and hyperæsthetic conditions generally.

[TABLE

| | Parts per thousand. | | | |
|---|---|---|---|---|
| | Name and Temperature (F.) of Spring. | Total Solids. | $CO_2$ c.cm. | Other important Constituents. |
| FRANCE | | | | |
| *St. Galmier*, Loire. — Used exclusively as table water. | Badoit 46·4 | 2·8 | 1500 | Sodium bicarbonate, 0·5 Calcium bicarbonate, 1·0 |
| *Renaison*, Loire. —Used exclusively as table water. | ... | 1·5 | 560 | Sodium bicarbonate, 0·2 Calcium bicarbonate, 0·6 |
| SWITZERLAND | | | | |
| *Fideris.*—Altitude 3360 feet. Indications: Anæmia, neurasthenia, dyspepsia. Season: June 15 to Sept. 15. | ... | 1·1-1·9 | 686-972 | Sodium bicarbonate, 0·6 Calcium bicarbonate, 0·2 Iron bicarbonate, 0·016 |
| GERMANY | | | | |
| *Apollinaris.* — See Alkaline Waters. *Geilnau.* — See Alkaline Waters. *Neuenahr.* — See Alkaline Waters. | ... | 2·2 | 1521 | Sodium bicarbonate, 0·9-1·2 Sodium chloride, 0·3-0·5 Sodium sulphide, 0·2-0·3 |
| AUSTRIA | | | | |
| *Giesshübl* . . . . . | ... | 2·0 | 1205 | Sodium bicarbonate, 1·2 Calcium bicarbonate, 0·3 |
| HUNGARY | | | | |
| *Eperies* . . . . . | Salvator Water. | 3·4 | 1200 | Calcium bicarbonate, 1·6 Magnesium bicarbonate, 0·9 Silica bicarbonate, 0·03 |

REFERENCE

1. J. Glax, *op. cit.* pp. 161 and 229.

# CHAPTER XXVIII

## MINERAL WATERS FOR INTERNAL USE

## Group A. Depurative

### *II. Stomachic and Diuretic* (continued)—*Simple Alkaline and Alkaline Salt Waters*

Waters that contain bicarbonate of soda as their chief ingredient are known as alkaline waters. The lowest limit of soda warranting the name is usually placed at one gramme per litre. But weaker spas are sometimes included, as for example, Mount Dore, which contains only 0·53 gramme to the litre, and which is usually placed in this category. The strongest spring of the class is Ignazbrunnen at Rohitsch in Styria, which contains 8·6 grammes per litre. Vals comes next with 7·1 grammes; then the springs of Vichy with about 5 grammes. Various other salts besides bicarbonate of soda are invariably present; but if in quantity large enough to have much therapeutic significance they would cause the water to be classified in some other group. When in addition to the bicarbonate the chloride of sodium is present in therapeutical quantity the term alkaline salt water is usually applied.

Lithium appears in several alkaline waters, but in such minute quantities as to have no therapeutic value. The form in which it usually occurs is, moreover, the chloride, which is devoid of solvent action on uric acid or its compounds. The carbonate of lithium, however, is found in two or three wells. The Königsquelle at Elster, the strongest lithium

spring of any kind, contains 0·1 per cent, that is, nearly a grain in a pint. The lowest dose of practical use is about fifteen grains daily.

Carbonic acid in greater or less amount is also usually present; and sometimes nitrogen and oxygen.

The alkaline waters are nearly all cold. Amongst the exceptions are the Neuenahr Sprudel, with a temperature of 40° C. (104° F.), and the Source de l'Hôpital at Vichy, with a temperature of 30·8° C. (87° F.).

These waters are all used more or less at table: the milder representatives of the group, such as Giesshübler and Apollinaris, chiefly on account of their sharp agreeable taste; the stronger members, such as the waters of Vals, Vichy, Bilin, and Fachingen, only when a definite therapeutic object is in view.

In physiological action the simple alkaline waters resemble the simple aerated waters with the addition of bicarbonate of soda. Bicarbonate of soda on reaching the stomach combines with the free acids there, carbonic acid being set free. The action of the drug on the system is largely determined by its fate in the stomach—whether it is converted into an easily absorbed salt or not.

The carbonates of soda have a low diffusion power, and even when they reach the duodenum unchanged, are not quickly absorbed. Though present in the blood in large amount the bicarbonate of soda is not usually taken up ready made, but is formed in the system. This may happen in two ways. The chloride of sodium ingested with the food or formed in the stomach passes readily into the system. Some of the chloride gives up its chlorine to supply the hydrochloric acid of the gastric juice, and the base thus set free unites with a portion of the carbonic acid constantly formed by the oxidation of fats and sugars. The vegetable salts of soda also are converted into bicarbonate through the oxidation of the acid.

Whether the alkalinity of the blood can be increased to any considerable extent by the administration of alkalies is a question still unsettled. According to some observers

any superfluous salt rapidly passes from the system, leaving no opportunity for any great accumulation. However, in the blood ash of dogs that had received a small amount of soda with their food, Dubelir found an increasing degree of alkalinity. Some storing up, therefore, does occur.

According to many bath physicians the long-continued use of the alkaline salts gives rise to a form of anæmia known as alkaline cachexia. However, in a case recorded in the *Medico-Chirurgical Transactions*, vol. v. p. 80, carbonate of soda to the amount of two ounces and a half daily was taken with impunity for months. The blood had a strong buffy coat; the urine was alkaline.[1] No ill effects were observed by Stadelmann and his pupils from long-continued doses of bicarbonate of soda. One person in the course of six or seven weeks took 600 grammes (about 21 ounces) of bicarbonate or citrate of soda without the smallest appearance of anæmia or cachexia. Reichmann also found no evil arise from the administration of the drug for several weeks.

Metabolism is variously affected according to different observers.[9] According to Seegen it is increased. The same view has been supported by Severin, Damourette and Hyades, and Mayer (Seegen, it should be noted, thought that sodium sulphate diminished nitrogenous metabolism but increased the oxidation of fats and sugars). According to Stadelmann and his pupils, tissue change is slightly diminished. The same conclusion was reached by Jawein, giving bicarbonate of soda in large doses—20 grammes (5 drachms) and citrate of soda in doses of 20 to 40 grammes daily. According to Burchard and Klemptner, metabolism is irregularly disturbed. Finally, according to Münch, Clar, and Ott, it is quite unaffected by carbonates of soda. Thus every possible variety of opinion has been upheld on the ground of exact experiment. From this discrepancy, however, we are not entitled to assume that bicarbonate of soda is of no great importance in regard to metabolism. Beaunis says:[2] "The alkalies (soda and potash) and especially the alkalies of the blood have an important office to fulfil in the oxidations which take place in the

organism. Many organic compounds indifferent to oxygen in ordinary conditions undergo oxidation rapidly in presence of an alkali, as, for example, the oxidation of glycose in Barreswill's reaction. Piotrowsky and Magawly have shown that the free organic acids are oxidised with much difficulty, and pass partly unaltered into the urine, whilst when they form alkaline salts with soda or potash they are very rapidly oxidised and transformed into carbonates (Wohler). According to some physiologists alkalies favour also the saponification and ultimate oxidation of fat." It may be that just as a certain amount of oil is required to enable machinery to work smoothly, while an increase of the oil only clogs the wheels and increases the friction, so a certain amount of sodic bicarbonate is required for the proper working of the animal machinery. According to circumstances a greater or less degree of alkalinity may be called for, and any change leading towards this level may produce increased efficiency of internal oxidation, while a lack or an excess would have the contrary effect.

The fate of bicarbonate of soda in the stomach is not yet absolutely established. Until recently the view was accepted that alkalies stimulate the flow of gastric juice, and that any excess of alkali left over after neutralising the free acids present causes an increased secretion of gastric juice sufficient to neutralise the remaining alkali and to make the reaction acid. Lately, however, this teaching has been called in question by Reichmann.[3] He aspirated the stomach contents at various intervals after the ingestion of a solution of bicarbonate of soda, but found the results the same as when pure water was taken. Confirmatory evidence has been furnished by Khigine,[4] who has investigated the subject afresh in experiments like Heidenhein's. He isolated a part of the fundus of the stomach, taking care to keep the nerve supply uninjured. The isolated portion was converted into a blind sac; one end of which was sutured to the abdominal wall so as to form a fistulous opening with the outside. The continuity of the stomach was established by joining the cut ends. The secretion into this blind sac was taken as typical of what was going on in the rest of the

stomach when food was actually in process of digestion. The ingestion of water caused active secretion of gastric juice; but acids, alkalies, and neutral salts yielded practically negative results.

By such a revolution in doctrine is affected not the value, but the explanation of the value, of bicarbonate of soda in certain morbid conditions.

On the movements of the stomach the alkalies in small doses appear to have a somewhat stimulant action; but whether direct or indirect and accidental is not certain. Excessive acidity of the stomach contents has a paralysing action on the muscular coat of the organ. Alkalies in so far as they relieve this condition excite peristalsis. The carbonic acid set free, with consequent distension of the organ, also excites gastric contraction.

Whether the carbonates of soda have any influence on bile, and if so, what the influence is, has been also a matter of some controversy. Several recent observers have been unable to discover that any of the reputed cholagogues exercise any action whatever on the liver. Nasse found that the flow of bile in a dog was lessened by bicarbonate of soda. Stadelmann inferred from the researches of Nissen and Mandelstamm that the alkalies are not cholagogues; that the bicarbonate, the chloride, the phosphate, and the sulphate of soda, the tartrate, the citrate, and the acetate of potash in small doses have no action on the biliary secretion, and in large doses diminish it without altering the amount of solid contents excreted (biliary acids, fats, colouring matter, etc.). He suggests three modes in which alkalies influence diseases of the liver; first by an alkaline action on the blood, whereby the bile becomes more alkaline; second, by an anti-catarrhal or mucous dissolving action; third, by a modifying action on the formation of the elements of the bile.

Becker found that the introduction of 1-2 grammes of bicarbonate of soda into the stomach of a dog diminished the pancreatic juice secreted and lowered its proteolytic action; whilst on the contrary the introduction of distilled water and still more of carbonated water increased the amount produced.

Bicarbonate of soda has but little action on the intestine. When passed on by the stomach unchanged it appears to have a slightly aperient tendency. This is probably, as in the case of saline aperients generally, owing to its low diffusion power, rather than to any direct influence on peristalsis or secretion.

Bicarbonate of soda when absorbed unchanged or when converted in the stomach into salts that are easily absorbed usually has a diuretic influence; but this action is not uniform and appears to depend on many circumstances that are not fully known. In any case the alkalies taken by the stomach cause the urine to become alkaline; and only during the excretion of the superfluous salt does the diuresis continue. The diuresis would seem therefore to be due to the absorption of water from the tissues by the alkali for its own solution rather than to a directly stimulant action on the kidneys.

### Therapeutic Uses

The ailments in which the alkaline waters are chiefly employed are affections of the mucous membranes of the respiratory, digestive, and urinary tracts. In certain general morbid conditions, also, such as chronic gout and rheumatism, they have a certain degree of popularity. At one time diabetes was supposed to be favourably influenced by waters of this class, especially when drunk at the source.

In chronic catarrhs of the pharynx, of the naso-pharynx, or of the larynx, bicarbonate of soda in solution has always been a valued remedy. By virtue of its solvent action it aids in the removal of thick and tenacious secretions, and renders the application of other remedies more efficacious. The alkaline waters in the form of warm sprays are inhaled more or less at all springs of this class. By keeping the parts clean one source of irritation at least is removed, and a gentle stimulus given, which in mild cases may be sufficient to start the diseased mucous membrane on the way to recovery. In dry catarrh of the bronchial tubes also the alkaline waters are beneficial; though in such cases the

presence of chloride of sodium is a distinct advantage, as we shall presently see.

Amongst digestive troubles in which the alkaline waters are useful are chronic catarrhal conditions of the stomach. In such cases every practitioner of medicine knows the value of soda given before meals. At mineral springs the usual dose ranges as a rule from one to two glasses, and may contain from 2 to 30 grains of the bicarbonate. Taken on an empty stomach, such a dose thins and washes away the catarrhal mucus clinging to the surface, and thus prepares the stomach for its next meal. The beneficial influence is heightened by the surroundings, the plain food, the quiet outdoor existence, the absence of the rush and worry of business or professional life.

Acidity due to fermentation, while temporarily relieved, is in the long run made worse by alkalies, unless care is taken to secure antisepsis by lavage or other means.

Where indigestion is due to lack of acid from anæmia or general debility, the alkaline waters are likely to do harm rather than good. The digestive ailments which are treated with so much success at alkaline spas can, as a rule, be equally satisfactorily dealt with at home, provided the same general conditions of food and agreeable mental and bodily occupation can be obtained. The difficulty of securing these conditions during the ordinary routine of work at home, and their presence at watering places without being sought, will account for much of the greater benefit derived from the spa treatment.

Dilatation of the stomach, at any rate in its severer forms, is best treated by washing out the stomach with cleansing, antiseptic, and astringent solutions, and the natural alkaline waters are very useful for the purpose.

Although the alkalies have not been definitely shown by physiological research to possess any influence over the secretion of the liver, they are commonly employed in many liver ailments, especially where there is reason to suspect obstruction of the bile ducts, whether from catarrh or gall-stones; and when combined with aperients they are

unquestionably of great use. Part of the benefit may possibly arise from increased alkalinity of the bile, though such increased alkalinity has not been proved to follow the ingestion of alkalies; but the depletion of the local circulation by the aperient is probably the chief factor in the relief.

On the intestine the alkaline waters have usually but little effect. When, however, from any reason they are hurried unchanged through the stomach, they appear to act after the manner of the saline purgatives.

Diseases of the urinary tract afford an extensive field of usefulness for the employment of the simple alkaline waters. In highly acid states of the urine, in uric acid concretions in the kidney or bladder, in catarrh of the bladder or of the urethra, these waters are of special benefit. In the use of the natural waters, too, there is less danger of giving an immoderate amount of bicarbonate of soda, whereby the urine would be rendered alkaline and the phosphates of lime precipitated.

In regard to oxaluria and its relations to the alkalis the most diverse opinions have been expressed. By Lehmann oxaluria has been ascribed to the hindrance to free oxidation of uric acid and sugar derivatives caused by the large supplies of carbonic acid carried into the blood by the alkaline bicarbonates. By Beneke it has been ascribed to excess of alkaline bases in the blood. According to Gallois oxaluria is best treated with bicarbonate of soda on the ground that the alkaline carbonates promote oxidation. Fürbringer found that oxaluria was at any rate not increased by bicarbonate of soda. (See also page 511.)

Diabetes was at one time supposed to be favourably influenced by the alkaline waters, and even still patients suffering from this complaint are commonly sent to Vichy or to Carlsbad. This mode of treatment arose from the view put forward by Mailhe that the disease was due to incomplete oxidation of sugar owing to lack of alkali in the blood. The doctrine has long passed away, but the practice founded on it still survives. Many patients are in reality much benefited by a course at Vichy or at Carlsbad; but

there is every reason to believe that the benefit is due not to the waters but to the careful regulation of the diet. The alkaline salts have been shown by many observers to have no power to diminish the formation of sugar, while in all cases the copious administration of water is injurious. Unless alkalies are called for on some independent ground, they should not be given in diabetes.

In gout all the alkaline spas claim to be of use. Sir William Roberts has shown reason to think, however, that the simple thermal waters are more suitable. As the matter is important, I will quote at some length from his *Croonian Lectures*, 1892: "In the gouty state, either from deficient action of the kidneys or from excessive introduction of urates into the circulation, or from some other cause, the normal quadriurate of soda lingers unduly in the blood and accumulates therein. The detained quadriurate circulating in a medium which is rich in sodium carbonate gradually takes up an additional atom of base, and is thereby transformed into urate. This transformation alters the physiological problem. The uric acid—or, rather, a portion of it—circulates no longer as the more soluble and presumably easily excreted quadriurate, but as biurate, which is less soluble, and probably also—either for that reason, or because it is a compound foreign to the normal economy—less easy of removal by the kidneys." "It is believed that the alkaline carbonates and phosphates administered internally, by increasing the alkalescence of the blood, enhance its solvent power on the material of gouty deposits, and thereby delay or prevent their formation. The experimental evidence laid before you entirely destroys this hypothesis. It has been conclusively proved that alkalescence, as such, has no influence whatever on the solubility of sodium biurate. It has, moreover, been shown that the addition of an alkaline carbonate to blood-serum impregnated with uric acid produces no appreciable effect on the process of maturation and the advent of precipitation of the crystalline biurate in the medium. The use of alkalies in gout has been advocated on another ground. It is held, in a vague sort of way, that

there is an undue prevalence of acid in the gouty system, and that the blood is less alkaline than it should be. In some quarters it is even believed that this is the primary vice of the gouty state, and that there exists a so-called 'acid dycrasia' which dominates the whole condition. I have been at some pains to ascertain what foundation there is for this belief; I have found very little of any kind, and none that is really valid."[5] Sir Wm. Roberts found also that carbonate of lithia, though it possessed a solvent power on free uric acid, had not, when added to blood serum or synovia, "the slightest effect in enhancing the solvent power of these media on sodium biurate, nor the slightest effect in retarding its precipitation from serum and synovia artificially impregnated with uric acid." In reference to mineral waters he goes on to say: "Now it has been conclusively shown that all the salts of soda act adversely on the solubility of sodium biurate and hasten its precipitation, and it may be inferred that the introduction of these salts into the circulation must tend to favour the occurrence of uratic depositions in the body. It is not, therefore, surprising to learn that, not infrequently, the first effect of these waters on a gouty patient is either to provoke a downright attack of gout or to aggravate the symptoms under which he was suffering. This event is now recognised by the physicians practising at these spas as a thing to be looked for, and experience has taught them the necessity of caution in regard to the quantity of the water to be taken by newcomers. They comfort themselves and their patients, however, in the belief that this preliminary storm is a necessary prelude to the calm amendment which is to follow. There is no doubt some foundation for this idea. It is no fiction that a gouty man, tormented with symptoms of irregular gout, is relieved by a regular arthritic attack. I presume that this arises from the complete, or approximately complete, precipitation of the urates floating in his blood and lymph into the structures of the joints. The urates are thereby as effectually removed from the vital fluids as if they were eliminated by the kidneys. But it must, I think, be allowed that this is

a rough mode of cure, and that it brings with it serious pains and perils of its own. My impression is that gouty persons should either entirely avoid springs which owe their activity to sodium salts, or use them very sparingly. It is difficult to believe that they can do any direct good, and easy to believe that they can do direct harm. If they do any good at all it must be indirectly, by acting on the liver and the intestinal tract; and we possess other means of effecting this purpose without inducing any collateral risk."[6]

The value of the alkaline waters in uric acid concretions of the kidney and bladder has been already pointed out. At the risk of some repetition a few more words from Sir William Roberts may be quoted, lest confusion should arise as to the sphere of the warning just given.[7] "There is, however, no doubt that there exists a special relation between uric acid, gravel, and gout; and the circumstance that uric acid figures as a common factor in both has led certain persons to the opinion that the two complaints are substantially one and the same. This notion is certainly not correct; and from a therapeutic point of view it is, I believe, a mischievous notion. It is a matter of common experience that many gouty people are never troubled with gravel, and, conversely, that many subjects of gravel are never troubled with gout. In both complaints there is an aberration of uric acid; but the error is essentially different in the two cases, both in regard to its site and in regard to its nature. In gout the error occurs on *this* side of the kidneys—in the blood and tissues—and the uric acid is precipitated in state of combination as a biurate; in gravel the error occurs on *that* side of the kidneys, and the uric acid is precipitated in the urine and in the free state. In the former the deposition takes place in the true interior of the economy; in the latter the deposition takes place in what is, strictly speaking, the exterior of the economy—that is to say, on the surface of a doubling of the external integument. These differences are, I believe, radical, and involve important distinctions both in regard to pathology

and in regard to treatment."[8] "I cannot recall a single instance in which a paroxysm of gout and a paroxysm of uric acid gravel broke out synchronously. And Sir Alfred Garrod, with a longer and still larger experience, gives me his testimony to the same effect. Some pertinent evidence on the point we are debating has been brought forward by Mr. Plowright of King's Lynn. He remarks that, residing as he does in Norfolk, the chief stone district in England, he has been struck by the comparatively small number of cases of gout which have come under his notice as compared with the number of stone cases. He further shows, by reference to the Registrar-General's reports, that there is no correspondence between the prevalence of gout and of stone in the several counties of England and Wales. Some of the counties which have a high death-rate from gout have a low death-rate from stone, and, conversely, counties with a high death-rate from stone have a low death-rate from gout. In Scotland, where gout is rare, stone is comparatively common."

To prevent the precipitation of uric acid in urine, and to dissolve the precipitate when it has occurred, the acidity of the urine must be diminished as much as possible, but without causing an alkaline reaction. Acidity becomes higher during prolonged fasting and sleep; "the period when there is most risk of precipitation in the kidneys is in the early morning during the two or three hours preceding breakfast." A single full dose of alkali at bedtime answers in mild cases of uric acid gravel. In severe cases an additional dose may be required two or three hours after breakfast and two or three hours before dinner. For this purpose Sir William Roberts prefers the citrate of potash in 40 to 60 grain doses in 3 or 4 ounces of water.

Used externally, the alkaline waters are more detergent in action than is plain water, but otherwise have no important distinguishing feature except in so far as they contain carbonic acid, the action of which has been already dealt with. These waters, though at one time employed nearly exclusively as baths, are now used almost wholly as drinking cures.

## ALKALINE WATERS

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|---|
| | | $NaHCO_3$. | NaCl. | $Na_2SO_4$. | $CaCO_3$. | Other important Constituents. | $CO_2$. c.cm. |
| FRANCE | | | | | | | |
| *Vals*, Dépt. Ardêche.—Altitude 790 feet. Climate mild. Indications: urinary and digestive ailments, anæmia. (See "Arsenical Waters.") Season: May 15 to October 15 | Magdeleine 55° | 7·2 | 0·16 | 0·23 | 0·5 | .. | 1040 |
| *Vichy*, Dépt. Allier.—Altitude 750 feet. Climate hot in summer. Indications: stomach and liver trouble, gravel, diabetes, gout. Season: May 15 to September 30 | Hôpital 88° | 5·0 | 0·5 | 0·3 | 0·6 | Sod. arsen. 0·002 | 541 |
| | Célestins 54° | 5·1 | 0·5 | 0·3 | 0·5 | 0·002 | 532 |
| | Grande Grille 106° | 4·8 | 0·5 | 0·3 | 0·4 | 0·002 | 460 |
| *Le Boulou*, Dépt. Pyrénées orientales.—Altitude 320 feet. Indications: same as Vichy. Season: May 1 to October 15 | Le Boulou 62° | 3·7 | 0·8 | ... | 0·06 | ... | 1210 |
| *Châteauneuf*, Dépt. Puy-de-Dôme.—Altitude 920 feet. Climate mild. Indications: dyspepsia, anæmia, rheumatism. Season: June 1 to September 15 | Grand Bain Chaud 100° | 1·2 | 0·4 | 0·5 | ... | Iron bicarb. 0·03 | 640 |
| *Mont-Dore*, Dépt. Puy-de-Dôme.—Altitude 3550 feet. Climate changeable. Indications: nasopharyngeal, laryngeal, and bronchial catarrhs, gouty and rheumatic affections, stiff joints, asthma, neurotic affections, hysteria. Season: June 15 to September 15 | Bertrand 113° | 0·5 | 0·36 | 0·07 | 0·34 | Silica 0·16 Iron bicarb. 0·02 Sod. arsen. 0·0009 | 180 |
| SWITZERLAND | | | | | | | |
| *Passugg*, Cant. des Grisons.—Altitude 2730 feet. Also a very mild iron spring. Indications: same as for Vichy. Season: May 20 to September 30 | Ulricus 46° | 5·4 | 0·8 | 0·08 | 1·0 | Silica 0·02 | 954 |

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|---|
| | | $NaHCO_3$. | NaCl. | $Na_2SO_4$. | $CaCO_3$. | Other important Constituents. | $CO_2$. c.cm. |
| GERMANY | | | | | | | |
| *Apollinaris*, Ahrweiler, Prussia. — Altitude 330 feet. Water wholly exported as table water | 69° | 1·2 | 0·5 | 0·3 | 0·06 | Silica 0·008 | 1500 |
| *Fachingen*, near Wiesbaden.—Water only exported. Indications: dyspepsia, gout, gravel | 50° | 3·6 | 0·6 | ... | 0·6 | Silica 0·02 | 905 |
| *Geilnau*, Hesse-Nassau, Prussia.—Water only exported | 50° | 1·0 | ... | ... | ... | ... | 1400 |
| *Obersalzbrunnen*, Silesia. —Altitude 1250 feet. Climate bracing. Indications: gout, catarrh of the air passages, dyspepsia. The minute quantity of lithia helps the reputation, if not the action, of the water. Season: May 1 to September 1 | Oberbrunnen 46° | 2·1 | 0·2 | 0·4 | ... | Lithii bicarb. 0·01 | 985 |
| *Neuenahr*, Rhenish Prussia. — Altitude 280 feet. Climate mild. Indications: diabetes and gall stones are specialities; catarrhal states of stomach, bowels, and respiratory passages; diseases of women. Season: May 1 to October 15 | Sprudel 104° | 1·0 | 0·1 | ... | 0·3 | ... | 490 |
| AUSTRIA | | | | | | | |
| *Bilin*, Bohemia.—Altitude 650 feet. Water chiefly exported. Indications same as for Vichy | Sauerbrunn 54° | 3·3 | 0·4 | 0·6 | 0·3 | Silica 0·06 | 1340 |
| *Giesshübl*, Bohemia. Only exported as table water | Sauerbrunn 46° | 1·2 | .. | 0·3 | 0·3 | Silica 0·06 | 1205 |

## ALKALINE SALT WATERS

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|---|
| | | $NaHCO_3$. | NaCl. | $Na_2SO_4$. | $CaCO_3$. | Other important Constituents. | $CO_2$. c.cm. |
| FRANCE | | | | | | | |
| *Royat*, Dépt. Puy-de-Dôme. — "French Ems." Altitude 1480 feet. Climate mild, hot in summer. Indications: gouty and rheumatic ailments, catarrhs of the respiratory, intestinal, and urinary passages, diabetes, obstinate skin affections, especially of gouty origin. Season: May 15 to September 15 | Eugénie 95° | 1·3 | 1·7 | 0·2 | 1·0 | Iron bicarb. 0·04 Silica 0·15 | 380 |
| | St. Victor | 0·8 | 1·6 | 0·11 | 0·01 | Sod. arsen. a trace Iron bicarb. 0·056 Silica 0·09 Sod. arsen. 0·004 | 1492 |
| *La Bourboule*, Puy-de-Dôme. — Altitude 2782 feet. Climate mild, moderately bracing. Indications: scrofula, especially in children, chronic rheumatism and rheumatoid arthritis, chronic skin diseases, naso-pharyngeal and bronchial catarrhs | Perrière | 2·8 | 2·8 | 0·2 | ... | Sod. arsen. 0·028 | ... |
| GERMANY | | | | | | | |
| *Ems*, Prussia.—Altitude 270 feet. Sometimes rather hot in summer. Indications: catarrh of digestive, urinary, and respiratory systems, chronic inflammation of womb and neighbouring organs, sterility, rheumatism, and gout. Season: May 1 to September 15 | Fürstenbrunnen 103° | 2·0 | 1·0 | 0·01 | 0·2 | Silica 0·05 | 500 |
| *Selters*, Hesse-Nassau, Prussia.—Used as table water; exported | 61° | 1·2 | 2·3 | ... | 0·4 | Silica 0·02 | 1140 |

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|---|
| | | $NaHCO_3$. | NaCl. | $Na_2SO_4$. | $CaCO_3$. | Other important Constituents. | $CO_2$. c.cm. |
| GERMANY—*continued.* | | | | | | | |
| *Roisdorf*, Rhenish Prussia. — Table water; exported | 53° | 1·1 | 1·8 | 0·5 | ... | 480 | ... |
| AUSTRIA | | | | | | | |
| *Luhatschowitz*, Moravia. —Altitude 3950 feet. In valley in Carpathian mountains. Climate mild. Indications: bronchial, gastric, and intestinal catarrhs, scrofula | Louisenquelle 44·6° | 8·0 | 4·3 | ... | 0·8 | Sod. iodide 0·02 Silica 0·06 | ... |
| *Gleichenberg*, Styria.— Altitude 990 feet. Climate mild, sheltered. Indications: especially respiratory ailments, catarrh of the pharynx, larynx, or bronchi; also catarrh of the stomach or of the urinary passages | Constantinsquelle 57° | 2·5 | 1·8 | 0·08 | 0·3 | Silica 0·06 | 1140 |

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# CHAPTER XXIX

## MINERAL WATERS FOR INTERNAL USE

### Group A. Depurative

### *III. Mild Intestinal Stimulants—Chloride of Sodium or Common Salt Waters*

The waters of this group are sometimes known as Halopegæ or Halothermals. Their characteristic feature is that chloride of sodium is the chief ingredient. The amount of salt varies considerably. Waters containing less than 1·5 per cent or 15 grammes to the litre are called mild salt waters; those with a larger proportion strong. Some springs generally recognised as belonging to this class contain a much lower proportion of salt. At Baden-Baden the quantity of salt to the litre ranges in different springs from 1·8 to 2·2 grammes; at Cannstatt, Würtemberg, the proportion is 1·9 per thousand; at Schwalheim, Hesse, 1·5 per thousand; at Battaglia, Italy, 1·6 per thousand; at Bourbon-Lancy, 1·3 per thousand. In the strong salt waters the range of salt is greater still. The Neuheim Kurbrunnen contains 15·4 per thousand. At Rheinfelden, in Switzerland, the water, which is not a spring, contains 311·6 grammes of salt to the litre.

Other salts are always present. Of these the most common are the chlorides of calcium and of magnesium. The bicarbonate and the sulphate of soda are seldom present in any therapeutic amount. Iodine and bromine in combination with various bases are found in many of these waters,

but only in small quantity. The richest iodine spring is found at Salzburg, in Hungary. It contains 0·25 grammes of iodide of sodium to the litre; but, owing to the large amount of other salts it contains, is unsuitable for drinking. Its solid constituents are about 203 per thousand. Zaizon, in Siebenbürgen, which, since the analysis in 1842 by an unknown chemist, has been credited with 0·2492 gramme per litre, has lately been shown to contain only 0·0016 gramme. Kreuznach has only 0·0014 gramme, or about $\frac{1}{40}$ of a grain of iodide of magnesium to the litre. Bromine occurs more rarely than iodine, but when present the amount is usually larger. In the Elmen spa bromide of magnesium is present to the extent of 0·589, or nearly 9 grains per litre. The proportion in the Oranienquelle at Kreuznach is nearly half as large. Carbonic acid is present in very many of the salt springs, and often in large quantity, the springs then being known as carbonated salt waters.

Some of these waters are warm, others cold. Amongst the best known of the warm springs are those of Wiesbaden, with a temperature of 68·7° C. (155·6° F.); those of Baden-Baden, with a temperature of 68·36° C. (155° F.); those of Bourbonnelles Bains, with a temperature of 58·75° C. (138° F.); those of Burtscheid, near Aix-la-Chapelle, with a temperature ranging from 60° to 74° C. (140° to 165·2° F.); those of Battaglia, in Italy, with a temperature of 71° C. (159·8° F.).

Chloride of sodium is a normal and essential constituent of the blood and of all the juices and secretions of the body. The proportion in the blood plasma is 5·54 per thousand. When the amount becomes greater, the excess is removed from the body by the kidneys; but the removal takes place rather slowly, and some days elapse before the quantity sinks to the normal proportion. A salt solution having about the same strength as the blood plasma—between 5 and 6 per thousand—is spoken of as normal saline solution. It is practically indifferent to the tissues, and becomes entirely so when made slightly alkaline, and isoviscous by

the addition of 2 per cent of gum acacia. Solutions much stronger or much weaker have an irritant action.

The influence of chloride of sodium on tissue change has been the subject of much controversy. Voit's experiments[1] seemed to show that an increased amount of salt causes a slight though definite increase of nitrogenous disintegration. In a series of observations extending over forty-nine days, C. von Voit found that with a meat diet and salt ranging from 0 to 20 grammes the excretion of urea was increased with the amount of salt, and became about 5 per cent greater with 20 grammes than with none. Part but not the whole of the increase seemed to be due to the larger quantity of water taken with the increased amount of salt. This view has not been confirmed by the more recent work of Katz, Dapper, and v. Noorden—according to whose experiments chloride of sodium does not affect metabolism.

Katz, while taking 1050 c.cm. of Harzburger Cordoquelle containing more than 15 grammes of chloride of sodium, found a slight diminution of nitrogen excretion in the urine; but this was almost exactly balanced by increase of nitrogen in the fæces. According to these observations neither the water nor the salt increases tissue change.

Chloride of sodium not merely passes readily itself throughout the tissues of the organism, but it aids in the diffusion of albuminous substances. Albumen injected into the rectum of an animal is not absorbed. When a little common salt is added, however, then it is absorbed.[2] Another physical property of salt explains much of its physiological action. If a tube closed by a membrane and containing a concentrated solution of salt be dipped into water, the salt solution draws the water through with great rapidity.

Chloride of sodium acts as a diuretic when the quantity of liquid is not sufficient to dilute the salt in the blood to the indifferent point. Until that point is reached fluid is abstracted from the tissues, causing the quantity of urine excreted to be for the time being greater than the amount of water ingested, and giving rise to a sensation of thirst.

When the amount of liquid, however, is sufficient to secure the necessary dilution, the urine only keeps pace with the greater amount of liquid drunk.

In the stomach chloride of sodium has been believed, until lately, to increase the flow of gastric juice and to cause augmented peristalsis. Recent researches, however, have thrown doubt on the old view.[3] Lerèche found in a patient with a fistula of the stomach that chloride of sodium diminished the acidity of the gastric juice in proportion to the dose given. Reichmann found that both strong (5-10 per cent) and weak (1-2 per cent) solutions lowered the acidity without increasing the amount of the gastric juice. Schüle arrived at the following conclusions as the result of careful observations on men with a test breakfast of 400 grammes of porridge (Mehlbrei). Small doses of chloride of sodium (5 grammes) have no perceptible effect on digestion; the hydrochloric acid is neither increased nor diminished. Large doses (16 grammes) diminish the secretion of hydrochloric acid considerably, as well as the entire acidity; the formation of peptone becomes deficient; the absorption of sugar is disturbed; the peptic strength of the gastric juice is lowered, as shown by artificial digestion experiments, and by the microscopic appearance of the test breakfast. Very large dozes (24 grammes) seem to cause at first a diminution, then a slight increase, of the acid secretion; but even here the depressing action outweighs the stimulating.

Although chloride of sodium applied to the mucous membrane of the stomach does not cause an increased secretion of gastric juice, yet when the salt is withheld the gastric juice becomes weak in acid. Probably there is much difference of reaction to chloride of sodium in different individuals. Many cases of excessive acidity of the gastric juice are benefited by diminution of the chloride of sodium ingested.

As already mentioned, chloride of sodium solution passes readily through membranes, and after leaving the stomach is, as a rule, readily absorbed. When the solution is very large in amount, it exerts a stimulant action on intestinal

peristalsis. When the solution is concentrated the result is the same, the bulk of the solution then being increased by the removal of fluid from the tissues, owing to the attraction of salt for water. An aperient effect, however, is produced only when the fluid reaches the lower bowel, and as the weaker solutions are quickly absorbed, they do not, as a rule, cause purgation.

Bunge [4] has pointed out how the chemical relationship between sodium and potassium salts bears on their physiological action. When a salt of potassium meets with common salt in solution a partial exchange takes place. Chloride of potassium and the sodium salt of the acid which was combined with the potassium are formed. When this occurs in the blood there is formed besides the chloride of potassium another salt not present in the blood normally, or at any rate not in such large proportion. This excess or foreign constituent is therefore carried off with the chloride of potassium by means of the kidneys. "Common salt is, therefore, withdrawn from the organism by the ingestion of potassium salts. This loss can only be made up from without, and this explains the fact that animals which live on a diet rich in potassium have a longing for salt." The investigations made by Bunge showed not merely that vegetable feeders require much salt, but that tribes of men which live entirely on animal food have a positive disinclination for salt. They consume the blood, however, which contains nearly all the chloride of sodium.

Landsteiner's experiments do not quite agree with Bunge's views.[5] Fifteen rabbits fed on a diet containing much potassium and fifteen fed on a diet containing little were found, after three and a half weeks, to have practically the same proportion of salts in their blood.

The pancreatic secretion is, according to Becker, diminished by the chloride as it is by the bicarbonate of sodium.[6]

Some experiments by Bickel [9] seem to show that the Kochbrunnen water of Wiesbaden, in comparison with distilled water, increases the flow of gastric juice, the acidity

of the secretion, and its digestive power. Other experiments by the same observer and Bergell,[10] also with Wiesbaden Kochbrunnen water, would indicate that the mineral water owes its digestive influence largely to its radio-activity.

## Salt Water Baths

A brine bath containing 1½-2 per cent of chlorine compounds is regarded as weak; 2-4 per cent as medium; 4-6 per cent as moderately strong; 6-12 per cent or more as very strong.

The temperature of the bath ranges, as a rule, from 32°-35° C. (89·6°-95° F.). A temperature from 32°-30° C. (89·6°-86° F.) or lower is found agreeable by fairly vigorous people. The duration of the bath most commonly varies between fifteen and forty-five minutes, but the limits in both directions are occasionally widened.

Salt-water baths have a much more stimulant effect than have ordinary baths of the same temperature. Prolonged dilatation of the surface vessels follows a temporary contraction, and the redness does not pass off for some hours.

The influence of salt water baths on metabolism has been the subject of much experiment and discussion; but no very positive conclusions have been obtained. The consumption of oxygen and the excretion of carbonic acid are probably greater in a salt water than in a sweet water bath of the same temperature; but the nitrogenous excretion is, to all appearance, not materially influenced by the saline contents of a bath.[7]

## Therapeutics of Salt Waters

Wherever salt waters occur they are used for bathing purposes, and in very many cases they are used also for drinking cures.

Fashion and caprice have had a good deal to do with the special reputation of various salt springs of similar composition in different ailments. Kreuznach is particularly

famed for its usefulness in glandular enlargements of scrofulous origin. Kissingen is best known for its value in catarrhal states of the bowels. Nauheim has acquired a special reputation in the treatment of diseases of the heart. Baden-Baden is resorted to chiefly for gouty and rheumatic troubles. Wiesbaden has almost as large a syphilitic clientele as Aachen, carrying out the same method of treatment. It may be added that the waters of Aachen itself deserve to be regarded as belonging to the common salt class.

In spite of this special differentiation of various springs, there are certain points in common amongst all mineral waters of this group. Though the physiological action of common salt is sufficiently indefinite and uncertain, its therapeutic action in disease is probably referable to two or three very simple and well established properties.

The action of common salt waters comes into consideration only as regards the excess over the amount ordinarily taken with the food. The amount used with the food is about 15 or 20 grammes daily, and the additional quantity taken during a course of these waters seldom reaches, and still more rarely exceeds, 20 grammes a day. Now the action of this surplus is what we have to account for. To a man in good health it seems to be indifferent. The most recent researches have failed to show that either the assimilation or the disintegration of tissue is accelerated by an increase in the amount of salt over the normal quantity.

In disease the properties that come chiefly into play are the facility of diffusion, the assistance it lends to the diffusion of albumen, and its attraction for water. Salt is readily diffused throughout the organism and the tissues; and they hold with tenacity even more than the normal amount, parting from it only gradually. The salt in leaving the cell takes with it some of the water of the tissues, which must be replaced by a fresh supply. By this process a washing out of the tissue is established; used-up products are carried off, and where for any reason tissue change has been sluggish or imperfect, the increased flow of unirritating fluid bearing with it albuminous material affords some at

least of the conditions for more active assimilation and disintegration of tissue. Thus an increase of salt, while not directly stimulating the cell, may in some circumstances aid in restoring its healthy activity. This no doubt is the secret of its usefulness in a large group of cases of defective or perverted nutrition.

As salt-water baths probably have a more definite action in stimulating tissue change, the combined internal and external use of salt waters is in many cases much more efficacious than either alone.

Chronic catarrhal conditions of the stomach and bowels furnish a large proportion of the visitors to the salt water spas. Amongst the cases that do well are those in which there is muscular atony or deficient secretion of gastric juice. For though not a direct stimulant of gastric juice, it indirectly removes one cause of insufficient gastric secretion. Salt waters are mainly useful by their cleansing and unirritating action. They wash away secretions which otherwise would hang about fermenting or decomposing. In such catarrhal states diarrhœa and constipation often occur in alternation, the diarrhœa representing an irritable mucous membrane with increased secretion and augmented peristalsis whereby food is hurried undigested along, leaving the intestine free from the stimuli of both normal and abnormal contents. Hence follows constipation with renewed irritation. Small doses of weak solutions have no aperient effect. Large doses, on the contrary, owing to their bulk are carried quickly along the intestine without being absorbed, and thus flush the entire tract. This flushing with unirritating fluid and the consequent increased peristalsis and improved circulation tend to remove the catarrhal condition.

In hyperæmia and cirrhosis of the liver these waters are of use in so far as they cause depletion of the portal system. For this purpose they are most efficacious when sulphate of sodium is also present.

Certain catarrhal affections of the air passages are treated with success by inhalations at the common salt spas. Naso-pharyngeal, laryngeal, and bronchial catarrhs with an irrit-

able condition of the mucous membrane and but little secretion are commonly relieved, the unirritating spray cleansing the surface and aiding in the removal of the secretions. In mild and recent cases such treatment often leads to recovery.

In the treatment of diseases of the circulatory system the derivative action of salt baths has proved of use. In dilated heart, with quick and irritable action, the results have been particularly satisfactory. Mild and carefully regulated gymnastic exercises form an important adjunct to the treatment at some baths. Nauheim has in recent years acquired a special reputation for this method of treating cardiac cases. It is important to remember that the indiscriminate employment of such treatment has been productive of evil results.

Nervous ailments dependent upon defective metabolism or upon disturbances of the digestive system, as is commonly the case with hypochondriasis and frequently with neuralgia, hysteria, and other functional affections, are likely to be benefited by the internal combined with the external use of the salt waters.

Chronic muscular rheumatism and kindred affections are generally much relieved by salt baths, as in fact by all other thermal treatment.

High in the list of conditions for which salt waters are useful stands the somewhat vague and indefinite group of affections spoken of as scrofulous. The term scrofula is used to signify a weakly constitutional state in young persons, characterised by a tendency to chronic inflammatory changes in the skin, in the lymphatic glands, in the joints, and in the periosteum usually, but not necessarily, of tubercular nature. Salt water baths, in so far as they improve the general nutrition, are likely to benefit such cases, but prudence is required lest quiescent tubercle should be stirred into activity. (See also pages 473-476.)

Some chronic skin affections of sluggish character occurring in scrofulous subjects derive benefit from salt baths; but unless the waters are specially indicated by the con-

stitutional condition of the patient, eruptions are, as a rule, quite as satisfactorily dealt with by the ordinary topical remedies. In nearly all eczemas and in all irritable states of the skin salt baths are to be avoided.

A special feature of all the brine baths is their value in the treatment of old pelvic exudations in women.

Diabetics have nothing to gain from salt water treatment internally or externally; but at most spas of this class provision is made for a suitable diet, so that diabetic patients can often be sent with advantage to such resorts.

## Sea Baths

Sea-water contains solid constituents varying in amount in different places from 1·2 per cent at Tavermünde on the Baltic to about 7 per cent at Marseilles on the Mediterranean. Of these solids the chief component is chloride of sodium, with chloride of magnesium in much smaller proportion—from one-tenth to one-third.

Sea-water, therefore, corresponds in strength to weak and medium salt baths already described. It differs from them essentially in the movement of the water and in the entirely different character of the surroundings. Salt baths are usually taken warm or hot; in sea-bathing the temperature is always low.

For sea-bathing a certain vigour of the circulatory system is essential. When the reaction is good and a glow of warmth is felt after the bath, sea-bathing acts as a powerful tonic and as a stimulant to metabolism. In the absence of such reaction sea-bathing becomes depressing, and lowers the vital forces generally. Sea-bathing is unsuitable for very young children, for very old people, and for the very anæmic. It is contra-indicated also in degenerative changes of the heart or of the arteries, in valvular defects, and in recent rheumatism. It should be avoided where there is a tendency to hæmorrhages.

Sea-bathing is most beneficial for scrofulous children, for persons who are run down, and for the neurasthenic

and hysterical—always provided that no contra-indication exists.

## SEA-WATER

The composition of sea-water, according to Jacobsen, is pretty constant in the high seas, but near the coast it varies considerably in different places, as shown in the following table from Kisch.[8]

| | Parts per thousand. | | | | |
|---|---|---|---|---|---|
| | Total Solids. | Chloride of Sodium. | Chloride of Magnesium. | Sulphate of Magnesium. | Sulphate of Calcium. |
| NORTH SEA (German Ocean). | | | | | |
| Near Ostend . . . | 28-30 | 22·4 | 5·2 | 4·4 | 0·7 |
| ,, Scheveningen . . | | 24·5 | 3·8 | 1·2 | 0·5 |
| ,, Heligoland . . | | 20·6 | 3·3 | 2·7 | 1·0 |
| ,, Norderney . . | | 21·7 | 8·2 | ... | 0·1 |
| BALTIC SEA. | | | | | |
| Near Travemünde . . | 10-19 | 8·8 | 2·8 | ... | 0·6 |
| ,, Doberan . . | | 10·9 | 4·6 | ... | 0·5 |
| ,, Putbus . . . | | 9·0 | 2·9 | ... | 0·4 |
| MEDITERRANEAN AND ADRIATIC. | | | | | |
| Near Venice . . . | 32-41 | 21·3 | 3·0 | 2·3 | 0·5 |
| ,, Leghorn . . . | | 32·8 | 4·7 | 2·7 | 1·0 |
| ,, Nice . . . | | 30·0 | 3·0 | 4·2 | 3·7 |
| ,, Marseilles . . | | 48·5 | 10·0 | 7·8 | 0·7 |
| ATLANTIC OCEAN. | | | | | |
| Near Hâvre . . . | 30-37 | 24·7 | 2·7 | ... | 1·1 |

[TABLE

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Total Solids. | Chloride of Sodium NaCl. | $CO_2$ in c.cm. per litre. | Other important Constituents. |
| **ENGLAND.** | | | | | |
| *Simple Salt Waters.* | | | | | |
| All the salt waters of the United Kingdom are cold | | | | | |
| **WORCESTERSHIRE.** | | | | | |
| *Droitwich.* — Strong brine formed by pure water passing over salt deposits. Indications:* muscular rheumatism, sciatica, gout, but acute attack sometimes induced, chronic pelvic inflammations, debility | ... | ... | 310 | ... | ... |
| *Malvern.*—Altitude 520 feet. Brine from Droitwich | | | | | |
| **CHESHIRE.** | | | | | |
| *Nantwich.*—Indications same as for Droitwich | ... | ... | 210 | ... | ... |
| **LEICESTERSHIRE.** | | | | | |
| *Ashby-de-la-Zouche.* — Altitude 400 feet. Indications: rheumatism, gout, scrofula; chronic skin diseases, such as eczema, psoriasis, acne, debility, and neuralgia | ... | ... | 19 | ... | $CO_2$ c.cm. |
| *Woodhall Spa.*—Indications: chronic rheumatic ailments; catarrhal states of the air passages, cystitis, chronic uterine or pelvic inflammations, liver troubles, skin diseases | ... | ... | 19 | ... | $Ca_2Cl$ 1·5<br>MgCl 1·3<br>Potass. bromide 0·06<br>Pot. iod. 0·007 |
| *Builth Well.*—Also sulphur and chalybeate springs | ... | ... | 12·5 | ... | $CaCl_2$ 3·5 |
| *Harrogate.* — (See Sulphur Waters) | Kissingen Spa | ... | 9·5 | ... | $FeCO_3$ 0·13<br>$BaCO_3$ 0·03 |
| *Llandrindod.* — Indications: gout, obesity, diabetes, "drink-craving." (See Sulphur and Iron Waters.) Season: May—October | Old Saline Spring | ... | 4·7 | ... | $CaCl_2$ 0·07 |
| *Llangammarch.* — Altitude 600 feet. Indications: heart diseases, scrofula | ... | ... | 2·6 | ... | $CaCl_2$ 1·2<br>$BaCl_2$ 0·1 |

* The indications throughout this table are those established by custom.

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Total Solids. | Chloride of Sodium NaCl. | $CO_2$ in c.cm. per litre. | Other important Constituents. |
| ENGLAND—*continued.* | | | | | |
| *Leamington.* — Indications: congestion of liver, obesity, chronic gouty and rheumatic conditions, scrofula, chronic pelvic inflammation | Pump Room Well, No. 1 | ... | 9·7 | ... | ... |
| | Public Fount | ... | 8·5 | ... | $FeCO_3$ 0·1 |
| *Cheltenham.* — Also chalybeate spring. Indications: debility from residence in hot climates, dyspepsia. Cheltenham now chiefly an educational centre | Pittville, No. 1 | ... | 7·0 | ... | $Na_2SO_4$ 1·3 $NaHCO_3$ 0·4 |
| SCOTLAND. | | | | | |
| *Bridge of Allan.*—Indication: dyspepsia | ... | ... | 5·9 | ... | $CaCl_2$ 4·7 $CaSO_4$ 0·5 |
| *Innerleithen.* | | | | | |
| *Bridge of Earn* (Pitkeathly). | | | | | |
| FRANCE. | | | | | |
| *Simple Salt Waters.* | | | | | |
| (A) Cold. | | | | | |
| BASSES-PYRÉNÉES. | | | | | |
| *Salies-de-Béarn.*—Altitude 100 feet. Water used chiefly for baths. Climate mild. Indications: scrofula, gout, rheumatism, chronic pelvic inflammations. Season: all the year round | Bayâa 58° | 255 | 245·0 | ... | ... |
| DEPT. DU JURA. | | | | | |
| *Salins.*—Altitude 1170 feet. Climate bracing; rather windy. Indications same as for Salies-de-Béarn. Season: June to October | Puits à Muire 50°-68° | ... | 22·7 | ... | ... |
| | Mother-lye | 318 | 168·0 | ... | ... |
| (B) Warm. | | | | | |
| DEPT. HÉRAULT. | | | | | |
| *Balaruc* on the Lagoon of Than. 27 kilometres south-west of Montpelier. Climate hot in summer, but tempered by sea breeze. Indications: gout, rheumatism, muscular weakness from old nerve lesions in torpid subjects. Mud baths a speciality. Season: May to October | Source des Romains 118° | 10·3 | 7·0 | ... | ... |

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Total Solids. | Chloride of Sodium NaCl. | $CO_2$ in c.cm. per litre. | Other important Constituents. |
| FRANCE—*continued.* | | | | | |
| DEPT. HAUTE-MARNE. | | | | | |
| *Bourbonne-les-Bains.*—Altitude 880 feet. Climate mild, but rather damp, and somewhat variable. Indications: scrofula, rheumatism, syphilis, old wounds, remains of old paralysis. Season: April 15 to October 15 | Source de la Place 137° | 7·5 | 5·7 | ... | Silicate of soda 0·12 |
| *Carbonated Salt Waters.* | | | | | |
| The only water of this class in France is Salins-Moutiers | | | | | |
| SAVOY. | | | | | |
| *Salins-Moutiers.*—Altitude 1623 feet. Climate hot in summer, but mornings and evenings cool. Indication: scrofula. Season: June to October | 95° | 16 | 10·7 | ... | Carbonic acid $CO_2$, 398 c.cm. |
| SWITZERLAND. | | | | | |
| *Simple Salt Waters.* Cold. | | | | | |
| AARGAU. | | | | | |
| *Rheinfelden.*—Altitude 900 feet. On left bank of Rhine, 12 kilometres from Bâle. Water which has passed over rock-salt beds is pumped up from a well sunk 420 feet. Climate hot in summer. Indications: scrofula, chronic gout and rheumatism, chronic pelvic inflammations. Season: May to September | 50° | 318 | 311·0 | ... | Sulph. of lime 5·0 |
| *Wildegg.*—The Wildegg water is not used at the place, but is sent to Schinznach, which is 4 kilometres distant. (See Schinznach) | 52° | 14·3 | 10·0 | ... | Sodium iodide 0·028 |
| VAUD. | | | | | |
| *Bex.*—Altitude 1435 feet. Climate mild; hot in summer. Also a cold sulphur spring. Grape cure in autumn. Indications: especially scrofula, | 59° | 170·2 | 156·6 | ... | ... |

| | Name and Temp. (F.) of Spring. | Parts per thousand. Total Solids. | Chloride of Sodium NaCl. | $CO_2$ in c.cm. per litre. | Other important Constituents. |
|---|---|---|---|---|---|
| SWITZERLAND—*continued.* | | | | | |
| also chronic inflammatory exudations, whether of the pleura or of the pelvic viscera. Season: May to October | | | | | |
| GERMANY. | | | | | |
| *Simple Salt Waters.* | | | | | |
| (A) Cold. | | | | | |
| PRUSSIAN RHINE PROVINCE. | | | | | |
| *Kreuznach.* — Altitude 350 feet. Climate mild, hot in summer. Water used both internally and externally. Indications: scrofula in all forms, chronic inflammations of the womb and adnexa. Season: May to September | Elisenquelle 54° | 11·7 | 9·4 | ... | Magn. brom. 0·04 Magn. iod. 0·0003 $CaCl_2$ 1·9 $BaCl_2$ 0·06 $FeCO_3$ 0·03 Silica 0·013 |
| (B) Warm. | | | | | |
| GRAND DUCHY OF BADEN. | | | | | |
| *Baden-Baden.*—Altitude 680 feet. Climate mild and rather humid. Indications: same as for Wiesbaden. Season: May to October, but open through the winter | Hauptstollenquelle 155° | 3·8 | 2·0 | ... | Lithium chloride 0·05 Arseniate of lime 0·0007 Silica 0·12 |
| *Carbonated Salt Waters.* | | | | | |
| (A) Cold. | | | | | |
| HESSE-NASSAU. | | | | | |
| *Soden-am-Taunus.* (See also Warm Carbonated Salt Waters). —Altitude 480 feet. Climate mild, sheltered, rather moist, hot in summer. Indications: catarrhal states of respiratory mucous membrane, scrofula, dyspepsia, uterine ailments. Season: May to October | Soolbrunnen 70° | 16·9 | 14·2 | 845 | ... |
| BAVARIA. | | | | | |
| *Kissingen.* — Altitude 633 feet. Climate mild. Indications: dyspepsia, gastric and intestinal catarrhs, congestion of liver or spleen, gall-stones, obesity, habitual constipation, | Soolsprudel 65·5° | 14·3 | 11·7 | 1024 | Calcium bicarb. 2·7 $FeCO_3$ 0·04 |
| | Schönbornsprudel 65° | 12·2 | 9·5 | 903 | Magn. sulph. 1·0 $FeCO_3$ 0·02 |

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Total Solids. | Chloride of Sodium NaCl. | $CO_2$ in c.cm. per litre. | Other important Constituents. |
| GERMANY—*continued.* scrofula, uterine ailments, catarrh of the respiratory mucous membrane, gout and rheumatism. Season: May to September | Rakoczy 51° | 8·5 | 5·8 | 1006 | Calcium bicarb. 1·4 $FeCO_3$ 0·03 |
| HESSE-NASSAU. *Homburg v. d. Höhe*, Taunus. —Altitude 627 feet. Climate mild, rather dry. Indications: same as for Kissingen. Season: May to October | Elisabeth-brunnen 51° | 13·3 | 9·8 | 1039 | Calcium bicarb. 2·0 Iron bicarb. 0·03 Lithium chloride 0·02 |
| HESSE-DARMSTADT. *Nauheim.* (See also under Warm Carbonated Salt Waters). —Altitude 480 feet. Climate mild. Indications: scrofula, neurasthenia, spinal irritation, rheumatic affections, chronic pelvic inflammations. In recent years the treatment of cardiac diseases has become a speciality of Nauheim. Season: May to September | Karls-brunnen 59° | 12·1 | 9·8 | 720 | Calcium chloride 1·0 |
| WALDECK-PYRMONT. *Pyrmont.*—Altitude 430 feet. Climate rather rough. Exposed to north and east winds. Damp. Indications: scrofula, dyspepsia. (See Iron Waters.) Season: May 15 to October 10 | Salzquelle 50° | 10·7 | 7·0 | 954 | Calcium carbonate 1·6 |
| (B) Warm. | | | | | |
| *Nauheim.*—(See above.) | Friedrich-wilhelm-quelle 95·3° | 35·3 | 29·3 | 579 | Calcium chloride 3·0 |
| *Soden.*—(See above.) | Soolsprudel, No. 24, 86° | 16·8 | 14·5 | 1525 | ... |
| HESSE-NASSAU. *Wiesbaden.* — Altitude 386 feet. Climate mild, hot in summer. Indications: catarrhal affections of the various mucous membranes, respiratory, gastric, intestinal, and | Koch-brunnen 155·6° | 8·2 | 6·8 | 200 | Calcium chloride 0·47 Calcium carbonate 0·41 |

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Total Solids. | Chloride of Sodium NaCl. | $CO_2$ in c.cm. per litre. | Other important Constituents. |
| GERMANY—*continued.* | | | | | |
| urinary, gout, rheumatism, scrofula, syphilis. Season: all the year round, but especially April to October | | | | | Silicic acid 0·059 |
| AUSTRIA. | | | | | |
| *Simple Salt Waters.* Cold. | | | | | |
| UPPER AUSTRIA. | | | | | |
| *Ischl,* Salzkammergut.—Altitude 1602 feet. Climate mild, rather moist, sheltered. Indications: scrofula, chronic rheumatism, catarrh of the respiratory passages and of the stomach and bowels. Season: June to September | Ischler Soole 59° | 245 | 236 | ... | ... |
| *Carbonated Salt Waters.* Cold. | | | | | |
| *Ischl.*—(See above.) | Klebelsberg-quelle | 5·3 | 4·3 | 400 | ... |

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# CHAPTER XXX

## MINERAL WATERS FOR INTERNAL USE

### Group A. Depurative

### *III. Mild Intestinal Stimulants* (continued)—*Alkaline Aperient Waters; and*

### *IV. Strongly Aperient Waters*

Carlsbad and Marienbad are the best-known representatives of the waters grouped under this title. They contain as principal ingredients the sulphate, the chloride, and the bicarbonate of sodium in therapeutically efficient quantities The amount of each of these salts varies independently. Bertrich water, containing less than one gramme per litre of any one ingredient, is recognised as belonging to this class. Amongst the stronger members of the group the Elster Salzquelle contains 6·3 grammes of sulphate of sodium per litre. Small quantities of chloride of magnesium are generally found, but not in amount large enough to require separate consideration. In the waters of Marienbad, Elster, and Tarasp carbonate of iron is present in appreciable doses. Carbonic acid gas appears in varying amount. These springs are nearly all cold; Bertrich, Carlsbad, and Châtel-Guyon are the only exceptions.

The most important constituent of these waters is the sulphate of soda; and we shall briefly examine its physiological action before stating the therapeutical uses of the waters generally. The physiological action of the bicarbonate

and of the chloride of sodium, which have already been fully considered, will be referred to only incidentally.

### Physiological Action of Sulphate of Soda and of Sulphate of Magnesia

Sulphate of soda is a normal constituent of most of the tissues and liquids of the organism, excepting milk, bile, and gastric juice. The amount altogether, however, is very small. The sulphates excreted in the urine by an adult man range from one to three grammes daily, but this amount includes other than sodium combinations.

The physiological action of sulphate of soda and of sulphate of magnesia is largely due to their attraction for water, and to the difficulty with which they pass through membranes. Intravenous injection of common salt, of Glauber's salts, or of magnesia, was found by Grawitz to cause a diminution of the specific gravity of the blood and an increased secretion of urine: while salt solutions introduced into the stomach attracted fluid from the blood, which in consequence became more concentrated. This result harmonises with Hay's observation that saline purgatives cause a transient increase in the proportion of the blood corpuscles. Von Mering introduced 400 c.cm. of 7·5 per cent salt solution with a specific gravity of 1054 into the stomach of a dog with a duodenal fistula; 787 c.cm. of fluid returned through the fistula, the specific gravity gradually sinking to 1009.[1]

In 1864 Seegen asserted that in dogs sulphate of soda in small doses (2 grammes) considerably diminished the disintegration of nitrogenous substances and increased the combustion of fat. Seegen used a faulty method of experimenting, and was sharply criticised by C. von Voit,[2] who thought that sulphate, like chloride of sodium, somewhat increases nitrogenous tissue change. Jacques Mayer,[3] however, has recently put forward evidence in favour of Seegen's view. The opinion that fat combustion is increased has received some support from Loewy,[4] who found the excretion

of carbonic acid and the consumption of oxygen augmented by the excitement of intestinal activity.

The action of the saline aperients was investigated by Dr. Matthew Hay. Hay found that saline purgatives cause a true increased secretion in the intestine, due not to osmosis, but to the irritant and specific properties of the salt, and also probably to its bitterness—the amount of the secretion varying with the nature of the salt, its amount, and the strength of the solution. Owing to the low diffusibility of the salt, the fluid secreted into the intestine is not readily absorbed. Hence fluid accumulates, and, causing increased peristalsis, reaches the rectum, where it gives rise to purgation. The secretion continues to flow until the solution reaches a strength of 5 or 6 per cent. The weaker or the more voluminous the solution of salt, the sooner is the maximum degree of dilution reached; and accordingly purgation follows with greater rapidity. Purgation will not ensue if water be withheld from the diet for one or two days previous to the administration of the salt in a concentrated form. The absence of purgation is due not to the want of water in the alimentary canal, but to its deficiency in the blood. When administered subcutaneously or injected into the blood these salts do not purge or excite intestinal secretion. Sulphate of soda exhibits no poisonous action when injected into the circulation; sulphate of magnesia, on the contrary, is powerfully toxic when so injected. Both salts when administered in the usual manner produce a gradual but well-marked increase in the tension of the pulse. The increase of the salt solution within the intestine coincides in amount with a corresponding diminution of the fluids of the blood. The blood recoups itself in a short time by absorbing from the tissues a nearly equal quantity of their fluids. The salt after some hours causes diuresis, and with it a second concentration of the blood, which continues so long as the diuresis is active. The intestinal secretion contains little organic, as compared with inorganic, matter. A large quantity of the salts of the blood may thus be evacuated. The amount of the normal constituents

of the urine is not affected. After the administration of the sulphate of magnesia much more of the acid than of the base is excreted in the urine. The bile and pancreatic juice appear to be but little affected.

### Therapeutics of Alkaline Aperient Waters

The waters of this group are amongst the most largely used in Europe for obesity, gastric and intestinal catarrhs, liver disturbances, including gall-stones, pelvic congestions or old exudations where vigorous action of the bowels is called for.

For obesity Marienbad is perhaps the most popular resort in Europe. The other members of the group, especially Carlsbad, are largely resorted to for the same trouble. The water probably acts by affording less time for food in the alimentary canal to be absorbed. The action of the water is materially aided by a rigid diet. This mode of taking down fat is suitable only for robust persons of costive habit.

Catarrhal states of the stomach and bowels are commonly much relieved by a course of these waters. By virtue of their bicarbonate of soda and common salt they are unirritating, and help to dissolve and sweep away tenacious and fermenting mucus. Thus they are often useful even when chronic diarrhœa or diarrhœa alternating with constipation is present. In dilatation of the stomach they are of use both for washing out the organ and for internal administration.

Functional disturbances of the liver from injudicious food or long-continued over-eating, from engorgement of the portal system, or from catarrh or obstruction of the excretory ducts, as well as cases of gall-stones, have all been found by experience to be favourably influenced by these waters, especially by the Carlsbad springs. The mode of action is by no means clear. Direct effect is unproved and even improbable. The bicarbonate, the chloride, the sulphate of sodium, Carlsbad salts, acetate of potash, sulphate of magnesia, as well as salicylate of soda in weak solutions, were all found by Nissen to be without effect

on the flow of bile in dogs; and in strong solution, on the contrary, they considerably lessen the secretion.[5] This effect is ascribed by Nissen to the abstraction of water by the concentrated solutions. Another point has to be borne in mind. A circulation of the bile was discovered by Schiff and confirmed by subsequent observers. A portion of the secreted bile is absorbed and again secreted by the liver. The flow is increased if bile be injected into the stomach or intestine, and diminished if the ordinary flow be diverted from the intestine. Now a saline aperient hurries on the intestinal contents, and so taps, as it were, the biliary circulation, and lessens the amount of bile absorbed. This process may help us to understand how the feeling of biliousness may be removed by a saline purge, but makes it more difficult to see why gall-stones should be benefited by the administration of these waters.

For diabetic patients Carlsbad and Marienbad are still popular resorts. There is no reason to think that any of the constituents of these waters or all of them together have any favourable influence on the disease, while the water if taken in large quantity is directly injurious. At these resorts, however, diabetics will have no difficulty in following a suitable regime in regard to food.

Chronic inflammatory affections of the female pelvic organs in patients of costive habit are amongst those for which the alkaline aperient waters are useful.

Gout, rheumatism, and arthritic affections generally are benefited only in so far as special indications are present in robust subjects for acting on the alimentary canal.

The duration of the "cure" with these waters is usually about twenty-one days. The continued use of them is apt to cause an irritable state of the intestinal mucous membrane.

## The Strongly Aperient Waters

The strongly aperient waters, of which Hunyadi Janos, Püllna, and Friedrichshall are the best known, contain as essential ingredients the sulphates of magnesium and of

sodium. Chloride of sodium is also usually present. These waters are as a rule but little if at all alkaline, the alkalinity being due to small quantities of calcium or magnesium carbonate. Æsculap water, however, is an exception, and contains a considerable proportion of sodium bicarbonate.

The waters of this group are exported largely; but are not used as local drinking cures.

Sulphate of magnesia has a more irritant action on the bowels than has the sulphate of sodium, and is more liable to cause griping Its mode of action has been sufficiently described in the section dealing with alkaline aperient waters.

These waters are admirably suited for occasional use when a saline purge is required, but are not adapted for continuous administration.

| | Parts per thousand. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $Na_2SO_4$. | $NaHCO_3$. | NaCl. | $CaCO_3$. | Other Constituents. | $CO_2$. c.cm. |
| FRANCE. | | | | | | | |
| *Châtel - Guyon*, Dept. Puy-de-Dôme.—Altitude 1254 feet. Climate mild, hot in summer, dry. Indications:* dyspepsia, dilatation of stomach (lavage with the water), gastro-intestinal catarrh, chronic constipation, congestion of the liver and engorgement of the portal system, tendency to congestions in head, in chest, or in pelvic organs. Season: May 15 to October 15 | Deval 90° | 0·5 | 0·9 | 1·8 | 2·1 | Iron bicarb. 0·06 Magn. chloride 1·5 Silica 0·1 | 560 |
| SWITZERLAND. | | | | | | | |
| *Tarasp*, Cant. des Grisons.—Altitude 3950 feet. Climate fairly bracing. Indications: chronic gastric and intestinal catarrh, liver ailments, gall-stones, habitual con- | Lucius 43° | 2·1 | 4·8 | 3·6 | 2·4 | Iron bicarb. 0·02 Silica 0·0009 | 1060 |

* The indications in this table are those established by custom.

| | Parts per thousand. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $Na_2SO_4$. | $NaHCO_3$. | NaCl. | $CaCO_3$. | Other Constituents. | $CO_2$. c.cm. |
| SWITZERLAND—*continued.* stipation, obesity, gout. (See also Iron Waters.) Season: May 1 to September 30 | | | | | | | |
| GERMANY. | | | | | | | |
| *Elster*, Saxony.—Altitude 1500 feet. Climate mild. Indications; gastric and intestinal catarrh, habitual constipation, especially with anæmia, chronic inflammation of uterus or adnexa. Season: May 15 to September 30 | Salzquelle 48° | 5·2 | 1·7 | 0·8 | 0·2 | Iron bicarb. 0·06 Silica 0·08 | 990 |
| *Bertrich*, Rhenish Prussia.—Altitude 540 feet. Climate mild. Water much the same as Carlsbad, but one-third of the strength. Indications: nervous complaints, catarrh of air passages, gouty and rheumatic affections. Season: May 1 to September 30 | Trinkquelle 90° | 0·8 | 0·7 | 0·2 | 0·16 | Magn. bicarb. 0·15 Silica 0·02 | 140 |
| AUSTRIA. | | | | | | | |
| *Marienbad*, Bohemia.—Altitude 2100 feet. Climate mild, rather moist. Indications much the same as for Carlsbad: obesity and old pelvic exudations. Diseases of women hold a more important place than at Carlsbad. Season: May 1 to September 30 | Ferdinandsbrunnen 48° | 5·0 | 1·8 | 2·0 | 0·78 | Iron bicarb. 0·08 Silica 0·1 | 1128 |
| *Franzensbad*, Bohemia.—Altitude 390 feet. Country flat and uninteresting. Climate mild. Indications: chiefly diseases of women, especially when combined with constipation, anæmia, or chlorosis. Season: May 1 to September 30 | Franzensquelle 51° | 3·2 | 0·7 | 1·2 | 0·2 | Iron bicarb. 0·03 Silica 0·06 | 1460 |

| | Parts per thousand. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | $Na_2SO_4$. | $NaHCO_3$. | NaCl. | $CaCO_3$. | Other Constituents. | $CO_2$. c.cm. |
| AUSTRIA—*continued.* *Carlsbad*, Bohemia.—Altitude 1230 feet. Climate mild, rather changeable. Indications: disorders of the liver, gall-stones, diabetes, catarrhal affections of the stomach and bowels, chronic constipation, gout, obesity, splenic enlargement; also urinary and uterine affections. Season: May 1 to September 30; but open all the year round | Sprudel 162·5° | 2·4 | 1 3 | 1·0 | 0·3 | Silica 0·07 | 100 |
| *Rohitsch*, Styria.—Altitude 720 feet. Climate mild. Indications: the same as for Carlsbad | Tempel-brunnen 51° | 1·9 | 1·0 | 0·1 | 2.2 | Silica 0·02 | 1000 |

| | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|
| | Total Solids. | $MgSO_4$. | $Na_2SO_4$. | $CaSO_4$. | NaCl. | $MgCl_2$. |
| Franz-Josephquelle, Buda-Pest . | 52·2 | 24·8 | 23·1 | 1·3 | ... | 1·7 |
| Apenta . . . . . . . | 43·8 | 24·4 | 15·4 | ... | 1·8 | ... |
| Hunyadi-Janos . . . . . | 48·2 | 22·0 | 22·5 | ... | 1·7 | ... |
| Birmensdorf, Switzerland . . | 31·0 | 22·0 | 7·0 | ... | ... | ... |
| Æsculap, Buda-Pest . . . | 37·2 | 17·2 | 13·9 | ... | 2·9 | ... |
| Sedlitz, Bohemia . . . . . | 16·4 | 13·5 | ... | 1·0 | ... | 0·3 |
| Püllna, Bohemia . . . . . | 32·7 | 10·8 | 9·6 | 1·5 | 2·5 | ... |
| Friedrichshall, Saxe-Meiningen, Germany | 25·6 | 5·1 | 6·0 | 1·3 | 7·9 | 3·9 |
| Kissingen, Germany (Bitterwasser) . | 25·2 | 5·1 | 6·0 | 1·3 | 7·9 | 3·9 |
| Rubinat, Spain . . . . . | 104 | 3·2 | 96·0 | Sulphate of lime and potash 2.1 | 2·0 | ... |

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# CHAPTER XXXI

## MINERAL WATERS FOR INTERNAL USE

## Group B. Tonic and Reconstituent

### *I. Hæmatogenic—Iron Waters*

The term Iron Waters is applied to mineral waters whose chief constituent is iron. But, as in the case of other waters, the name is used more or less arbitrarily and not very consistently.

The iron waters are divided into two classes according as the metal occurs as carbonate or as sulphate.

I. The carbonate of iron waters are by far the more numerous and more important. With a few exceptions they are cold; and they generally contain a good supply of free carbonic acid, which disguises the disagreeable styptic taste of the iron, and at the same time renders them more grateful to the stomach. The amount of carbonate of iron ranges from 1 to 20 centigrammes per litre. Other constituents are seldom present in any important quantity, the total amount of solids not often reaching 3 grammes, though it may exceed 6 grammes, as in the case of some Franzensbad springs.

II. The sulphate of iron waters are distinguished by the large amount of iron they contain, the proportion ranging from 10 centigrammes to more than 4 grammes per litre. Some of the waters of this group are rich in arsenic, Roncegno water having as much as 0·15 ($2\frac{1}{2}$ grains) per litre.

### PHYSIOLOGICAL ACTION OF IRON

From the remotest period the preparations of iron have been held in the highest repute in the treatment of anæmia;

and their value is attested equally by the empirical physician of olden times and by the scientific physician of to-day. In recent years, however, their efficacy has been questioned by physiologists and experimental pharmacologists.

It was found that iron given by the mouth can be recovered almost entirely from the fæces, increasing only slightly the amount removed by the kidney. It was found also that solutions of iron salts thrown into the circulation give rise to toxic symptoms of much the same character as those produced by an overdose of arsenic or of antimony: fall of blood pressure and great depression of the circulation; serious gastro-intestinal disturbance, such as vomiting, diarrhœa, and sometimes bloody stools; and finally inflammation of the kidneys. At the same time the metal was excreted by the kidneys as well as by the bowels. From these facts, especially the non-excretion by the kidney of iron administered by the mouth, it has been inferred that the inorganic iron salts are not absorbed at all from the intestinal tract. This view was put forward by Cl. Bernard, and it prevails largely even at the present day. The facts are admitted; but the inference, whether true or not, is obviously a *non sequitur*. The kidneys are not normally the chief or even an important channel for the elimination of iron; and when they undertake to carry off a portion of the excess artificially thrown into the circulation, the result is damage to the structure of the organ. The chief path of excretion has been found by many observers to be the intestinal tract. Buchheim and A. Meyer[1] found that a few hours after the injection of iron salts into the jugular vein of fasting animals the intestinal mucous membrane was covered with secretion rich in oxide of iron, whilst the urine contained but small quantities of iron. According to Dietl and Heidler, the metal passes out especially by the colon and cæcum, the removal probably taking place not through the glands, but by means of the leucocytes and epithelium. It is evident, therefore, that as iron is thrown out of the system into the intestinal tract for excretion, it is necessary, in order to know whether the metal is

2 D

absorbed from the intestine, to examine, not the amount of the metal in the fæces, but the amount in the organs, tissues, and fluids of the body. Experiments on these lines have been made by Gottlieb and by Kunkel. Kunkel fed white mice on bread, some with and some without the addition of liquor ferri oxychlorati. After incineration of the animals, the intestines being excluded, he found in

| | |
|---|---|
| Normal mice . | 13·2 mg. of iron per 100 grammes body-weight. |
| Iron-fed ,, . | 40·0 ,, ,, ,, ,, |

In another experiment he fed two young dogs of the same litter, one on meat alone, the other on meat with liquor ferri oxychlorati. The incineration of the various organs yielded the following results :—

| | Normal Animals. | Iron-fed Animals. |
|---|---|---|
| In blood . . . | 40·9 | 45·2 mg. iron. |
| ,, liver . . . | 16·5 | 51·2 ,, |
| ,, intestine . . | 36·0 | 43·0 ,, |
| ,, muscle . . . | 33·6 | 33·6 ,, |

The liver and spleen are especially rich in iron. Dietl and Heidler found that inorganic as well as organic iron preparations are absorbed exclusively in the duodenum, and chiefly by the lymphatics. This latter point has been confirmed by Gaule.[2]

In any case, however, the amount of iron absorbed must be very small. The entire amount of iron in the blood of a man 10 or 11 stones in weight is only from 2 to 2·5 grammes, or from 30 to 40 grains, and the quantity contained in the rest of the body probably half as much. The quantity included in the daily ration of a French soldier was calculated by Boussingault to be from 0·0661 to 0·078 grammes, or about 1-1¼ grains.

Iron is normally found in nearly all the excretions, the entire amount daily removed from the body being, on the average, about 5 centigrammes, or about ⅚ of a grain.

That the amount of iron absorbed is but a small proportion of the medicinal doses ordinarily given is highly probable; and yet in smaller doses the efficacy of the drug is very much less.

Rabuteau[3] found by experiments on himself that the perchloride of iron (12 centigrammes daily) does not increase the secretion of urine; but that it raises the acidity in a marked degree as well as the weight of the solid constituents, especially the urea. An increased excretion of urea from the employment of Pyrmont water was noticed by Valentiner, and from Schwalbach water by Genth. Munk[4] was unable in experiments on dogs to find that iron had any influence on nitrogenous excretion.

The following analyses by Andral and Gavarret show the influence of iron on the blood in two cases of chlorosis:[5]

| | Case I. | | Case II. | |
|---|---|---|---|---|
| | Before Iron. | After Iron. | Before Iron. | After Iron. |
| Water in 1000 parts . | 866·7 | 818·5 | 852·8 | 831·5 |
| Fibrin . . . . . | 3·0 | 2·5 | 3·5 | 3·3 |
| Blood corpuscles . . | 46·4 | 95·7 | 49·7 | 64·3 |
| Solid residuum of serum . | 83·9 | 83·3 | 94·0 | 100·9 |

Dr. Andrew Smart[6] has shown by a series of exact observations the relative value of different iron preparations in causing an increase of hæmoglobin and of red blood corpuscles in anæmia. The sulphate of iron was found to be the most active preparation; then came the saccharated carbonate; the syrup of the protochloride was ranked third, but had the drawback of readily causing nausea unless when given in very small doses. It will be remembered that, according to Rabuteau,[7] reduced iron, the carbonate, the sesquioxide, and even the perchloride, are converted into the protochloride before absorption can take place.

Dr. R. Stockman[8] found the subcutaneous injection of citrate of iron solution a most efficacious method of treating anæmia and chlorosis.

Lépine[9] also praises the administration of citrate of iron hypodermically, giving 0·1 - 0·15 gramme (about $1\frac{1}{2}$ - $2\frac{1}{3}$ grains) of the salt in a 4 per cent solution. These doses, though larger than what are usually given subcutaneously, caused no bad effects. With still larger doses, however, there is danger of toxic symptoms.

The iron waters are chiefly employed in anæmia and in affections more or less traceable to anæmia. In many cases, especially in girls and young women, where the ordinary pharmacopœial preparations of iron are not well borne, a course of waters at Schwalbach, for example, or at St. Moritz is found to aid greatly in starting the patient on the road to recovery; the good influence being no doubt largely due to the pure, bracing air and pleasant surroundings, and, especially in the case of St. Moritz, to the influence of altitude.

Anæmia with debility, following malaria, is often greatly benefited by iron waters. A high altitude is, however, even more efficacious. At St. Moritz both elements are combined to the greatest advantage.

Atonic dyspepsia as well as chronic diarrhœa rank amongst the ailments for which iron waters are considered particularly suitable.

Hysteria, hypochondriasis, neuralgias, and other neuroses dependent on debility or anæmia derive great benefit from iron waters, especially when aided by the invigorating air of the mountains. Schwalbach and St. Moritz are amongst the best resorts for this purpose.

Diseases of women may almost be considered the speciality of the iron spas, many of which are known as "ladies' baths." Irregularities of menstruation of all kinds and uterine catarrhs furnish a large contingent of cases to most of these resorts. Amongst the Germans and Austrians, Elster and Franzensbad are the most popular baths in such cases; amongst the English, Schwalbach. All have a great reputation for the cure of sterility in women.

A.—Carbonated Iron Waters.

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Total Solids. | Iron Bicarb. | $CO_2$ c.cm. | Other important Constituents. |
| ENGLAND. | | | | | |
| YORKSHIRE. | | | | | |
| *Harrogate.*—(See also Sulphur waters) | Carbonate of iron spa 51° | 6·0 | 0·08 | ... | ... |
| *Tunbridge Wells.*—Climate bracing. Indications: * anæmia and debility. Malarial cachexia said not to do well. Duration of course two months. Season all the year round. The waters of Cheltenham, Leamington, Strathpeffer, Llandrindod, Llanwrtyd, and of many other spas contain minute quantities of iron. | | ... | 0·065 | 71 | ... |
| FRANCE. | | | | | |
| VOSGES. | | | | | |
| *Bussang.* — Altitude 2220 feet. Mild mountain climate. Indications: anæmia, dyspepsia. Waters exported. | Source des Demoiselles 52° | 1·5 | 0·0029 | 500-1000 | Arseniate of iron 0·0012 |
| HÉRAULT. | | | | | |
| *Lamalou.* — Altitnde 630 feet. Climate rather warm, but heat tempered by sea breeze. Indications: chlorosis, scrofula, neurasthenia, uterine ailments, rheumatism, diseases of the spinal cord. Charcot used to send many cases of locomotor ataxia. Season: May 1 to Oct. 15. | Capus 59° | 0·44 | 0·056 | 374 | Arseniate of soda 0·001 |
| SWITZERLAND. | | | | | |
| GRISONS. | | | | | |
| *St. Moritz Bad*, Upper Engadine. — Altitude 1770 metres (=5820 feet). Bracing mountain climate. Indications for waters: anæmia and debility. As climatic resort useful in consumption, especially in torpid cases with fair vitality. Season for baths: June 15 to Sept. 15. As climatic resort both summer and winter. | Paracelsus-quelle 42° | 1·7 | 0·04 | 1717 | Calcium bicarb. 1·2 |

* The indications in this table are those established by custom.

CARBONATED IRON WATERS—*continued.*

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Total Solids. | Iron Bicarb. | $CO_2$ c.cm. | Other important Constituents. |
| SWITZERLAND—*continued.* | | | | | |
| *Tarasp*, Lower Engadine.—Altitude 3886 feet. Climate hot in summer, but mornings and evenings cool. Indications: see Alkaline Aperient Waters. All the springs contain a little iron. Season: June 1 to Sept. 16. | Bonifacius-quelle 45·5° | 5·1 | 0·03 | 1025 | Calcium bicarb. 2·9 Sodium bicarb. 1·2 Magnes. bicarb. 0·5 |
| BELGIUM. | | | | | |
| *Spa*, Prov. of Liège.—Altitude 820 feet. Climate bracing, but rather variable. Indications: anæmia, chronic gout and rheumatism, neurasthenia, Bright's disease, uterine ailments. Season: May 1 to Oct. 31. | Pouhon-Pierre le Grand. | 0·6 | 0·19 (according to some only 0·07) | 1288 | ... |
| GERMANY. | | | | | |
| *Homburg*, Hesse-Nassau.—Altitude 621 feet. (See Salt Waters) | Stahl-brunnen. 50° | 8·2 | 0·1 | 1082 | Sodium chloride 5·8 |
| *Schwalbach* or Langen-schwalbach, Hesse Nassau.—Altitude 1042 feet. Surrounded by woods. Climate hot in summer, with cool mornings and evenings. Indications: anæmia, nervous and uterine ailments dependent on anæmia. Season: May 1 to Sept. 30. | Stahl-brunnen. 48° | 0·6 | 0·08 | 1570 | ... |
| SAXONY. | | | | | |
| *Bad Elster.*—(See Alkaline Aperient Waters.) | Moritzquelle 50° | 2·2 | 0·08 | 1266 | ... |
| AUSTRIA. | | | | | |
| BOHEMIA. | | | | | |
| *Marienbad.*—(See Alkaline Aperient Waters.) | Ambrosius-brunnen 48° | 0·8 | 0·16 | 1173 | Silica 0·14 |
| *Franzensbad.*—(See Alkaline Aperient Waters.) | Stahlquelle 54·5° | 3·1 | 0·07 | 1528 | Sodium sulphate 1·6 Silica 0.08 |

B.—SULPHATE OF IRON WATERS.

| | Name and Temp. (F.) of Spring. | Parts per thousand. | | |
|---|---|---|---|---|
| | | Total Solids. | Iron Sulphate. | Other important Constituents. |
| ENGLAND. | | | | |
| *Harrogate.* | Alum Well | 5·6 | 2·1 | ... |
| AUSTRIA. | | | | |
| TYROL. | | | | |
| *Levico.*—Altitude 1760 feet. Climate mild, hot in summer. | Strong spring 51° | 7·1 | 2·5 | Sulphate of aluminium 0·6 Arsenious acid 0·008 |
| | Weak spring. | 1·7 | 0·9 | Arsenious acid 0·0009 Sulphate of aluminium 0·1 |

Waters of this type—sulphate of iron waters with arsenic—are found also at Roncegno in the Tyrol, Recoaro in Italy, and various other places. The daily dose ranges as a rule from one to eight tablespoonfuls.

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# CHAPTER XXXII

## MINERAL WATERS FOR INTERNAL USE

### Group B. Tonic and Reconstituent

### *I. Hæmatogenic* (continued)—*Earthy or Lime Waters*

The earthy waters have been the subject of much controversy. By many authorities the constituent to which they owe their name is hurtful in the very ailments for which these waters have acquired their chief reputation. Any good influence is ascribed, in spite of the lime, to the water alone, or to any bicarbonate of soda that may be present. The lime is held to be injurious as a rule, and, at best, inert. The presence of lime in calculi of various kinds, in gouty concretions, and in atheromatous arteries has been held to indicate that the administration of lime is dangerous when there is a tendency to these conditions. Other authorities point to the presence of lime in all the tissues and secretions of the body, to show that, as a normal constituent of the body, a certain supply is required to replace the losses that occur in the ordinary course of tissue change. When animals are fed with food from which the lime salts have been removed, various defects in nutrition have been proved to follow. The animals fail generally, and the bones become thin and porous. In the obsolescence of tubercle lime salts are deposited, a process which, it is supposed, could not readily take place if the lime in the blood were below its normal level.

We must admit that our knowledge of the position occupied by lime in regard to the general nutrition is very

scanty. We know that it is an essential constituent of the body; but we know not by what mechanism in some disorders of nutrition there is an increased wasteful outflow of the substance from the organism; while in other disorders there is a tendency to its deposition in certain tissues. There is no proof that the increased administration of lime will compensate physiologically for the augmented outflow, or that the withholding of lime from the food will hinder the perverse deposition of the circulating lime in certain tissues. The fault lies deeper, probably in an altered state of the tissues themselves.

Calcium phosphate is present in blood-corpuscles to the extent of 0·114 per thousand, and in the liquor sanguinis to the extent of 0·311 per thousand.[1]

The researches of Wright have shown the relation between the coagulability of the blood and the amount of lime salts in solution. Milk is no longer coagulable after the calcium has been precipitated. Urticaria and chilblains have been traced by Wright to defective blood coagulability, which could be relieved by the administration of the lime salts.

Lime occurs in most foods. Cow's milk contains 1·6 per thousand, but human milk only 0·3 per thousand. In the following table several articles of diet are arranged according to their richness in lime (CaO).

In 100 parts of dried substance the proportions are:[2]

| | |
|---|---|
| Beef | 0·029 |
| Wheat | 0·065 |
| Potato | 0·100 |
| Egg-albumen | 0·130 |
| Peas | 0·137 |
| Human milk | 0·243 |
| Yolk of egg | 0·380 |
| Cow's milk | 1·510 |

The amount of lime required daily has been determined for various animals at different ages; but for man the amount has not yet been made out. Of the lime salts taken in food a very large proportion—probably, at least, four-fifths—is not absorbed, but simply passes out by the bowel.

In the degree of solubility of the various salts of lime lies much of the difficulty of the subject. The chloride of calcium is extremely soluble both in alcohol and in water, and is probably readily absorbed by the system. The acid phosphate and the lactate are also moderately soluble. The sulphate and the carbonate dissolve only slightly in pure water, but somewhat more freely in water containing carbonic acid. Both of these almost insoluble salts are found in nearly all mineral waters, and in fact they are almost the only lime salts that occur in any quantity in waters used for drinking. The sulphate is not absorbed, but passes out with the fæces. How much of the lime existing as carbonate is taken into the system depends entirely upon the solubility of the combinations it forms in the stomach and intestines. A certain amount as chloride or lactate is probably always absorbed.

From the foregoing considerations we see that while lime may be a tonic in many conditions of the system, the least satisfactory way of administering it is by means of mineral waters. When it is given with a therapeutic aim one of the soluble and readily absorbable preparations should be selected, such as the chloride or acid phosphate.

The following table, showing the ailments in which the various waters of this class are employed, was drawn up by the late Dr. Macpherson:[3]

| | |
|---|---|
| Pulmonary affections (including tuberculosis and rachitis) | Lippspringe, Weissenburg, Leuk, B. de Bigorre, Pisa, Baden S., Bath, Bristol. |
| Urinary affections . . | Contrexéville, Vittel, B. Bigorre, Leuk, Pisa, Bath, Bristol. |
| Affections of stomach and intestines | Vittel, B. Bigorre, Contrexéville, Pisa, Bath, Bristol. |
| Biliary affections . . | Weissenburg, Contrexéville, Vittel, Pisa, B. Bigorre, Bath, Bristol. |
| Gouty affections . . | Contrexéville, Vittel, Baden, B. Bigorre, Leuk, Pisa, Bath. |
| Diabetes . . . | Contrexéville, B. Bigorre, Pisa, Bath, Bristol. |
| Cutaneous affections . | Bath, Leuk, Weissenburg, B. Bigorre. |
| Sterility . . . | Pisa, Baden, Contrexéville, Leuk, B. Bigorre, Bath (thermals generally). |

Owing to experience or fashion, however, several of these springs are devoted almost wholly to certain groups of disease. Lippspringe and Weissenburg have a special reputation in respiratory troubles, particularly consumption. Leuk (Louèche les Bains) is chiefly noted for its value in skin diseases, especially chronic dry eczema and psoriasis occurring in lymphatic or scrofulous subjects. Contrexéville and Vittel have been esteemed mostly in urinary ailments, gravel, and gout. Bath is frequented chiefly by sufferers from rheumatism.

The earthy waters chiefly employed in urinary affections are those of Contrexéville, Vittel, Pougues, Wildungen, and Hersterquelle in Driburg. All these waters contain a fair proportion of the bicarbonate of lime. The inert sulphate is also present in all but the Wildungen springs. The urinary ailments, which are most commonly treated at these resorts, are chronic catarrh of the bladder or of the kidney, stone or gravel, and the "uric acid diathesis." In all these ailments the value of alkaline waters is universally recognised. In neutralising acidity the bicarbonate of lime acts like the alkalies, and diminishes the acidity of the urine. Absorption into the blood does not appear to be necessary in order that this result should take place. When the lime forms insoluble compounds with acids in the stomach and intestines, it prevents the absorption of these acids into the system, and thus indirectly augments the amount of free alkali in the circulation. The absorption of lime salts is sometimes presumed to be injurious if uric acid exists in excess in the blood or tissues, or if there are concretions in the urinary apparatus. In such conditions the uric acid is supposed to enter into combination with the lime, forming an insoluble compound, which would be deposited in the tissues or around concretions already formed. However, in the treatment of uric acid concretions, von Noorden[6] prefers calcium carbonate or vegetable salts of the same base to salts of lithium or sodium. The calcium salts cause removal of phosphates through the intestines, thus lessening the phosphates in the urine. He has used

this treatment in twenty-one cases with excellent results. From two to four grammes, or even as much as ten grammes may be necessary to remove from the urine the monophosphate of sodium which renders urine particularly insolvent. The biphosphate is actively solvent.

There is incontrovertible evidence that beneficial results are obtained in catarrh of the bladder and in gravel from the waters of Wildungen, Contrexéville, Vittel, and other springs of the same class. The efficiency of the Contrexéville waters in these ailments is attested by Sir F. Cruise.[4]

We may remember, too, that a famous quack remedy of former days, Miss Joanna Stephens's *Receipt for the Stone and Gravel,* was made of calcined egg shells and snail shells, and consisted therefore of oxide of lime. Its virtues were so favourably reported upon by a medical committee appointed to examine into the efficacy of the treatment, that Parliament in 1739 purchased the secret of its manufacture for the nation at a cost of £5000.[5] As soon as its composition was known the remedy fell into disrepute.

The administration of lime to old people is by many considered undesirable lest the tendency to atheromatous changes should be increased. Yet cow's milk, which contains more lime than almost any mineral water, is given without hesitation.

The question is still unsettled whether, in the treatment of gravel and catarrh of the bladder, equal advantage may not be obtained from alkaline water without the lime salts. In either case the favourable result is due mainly to increased diuresis and diminished acidity of the urine.

In rheumatic conditions the waters of Bath, of Contrexéville, and of Leuk are also largely resorted to. In these affections they are used externally as well as internally. Massage and other subsidiary aids to treatment are commonly employed. The results are, as a rule, very gratifying.

As the sulphate makes the water heavy and indigestible

when not inert, while the bicarbonate is an active antacid, the nature of the lime salt should be borne in mind. The waters are, accordingly, divided into two groups, and are placed in order of richness in the respective lime salt.

## Silica in Mineral Waters

Silica in minute quantities is found in a great number of mineral waters, though not always mentioned in analyses, as it is sometimes supposed to render water for drinking heavy to the stomach.

The fact that silica in some form is found in almost all animal and vegetable tissues has for some few years directed greater attention to the importance of this substance in the animal economy. Silica is especially abundant in the more resistant tissues, like skin, tendon, dura mater, fascia, hair, and feathers. It is present both in the yolk and in the white of eggs.

A deficiency in silica in the blood and in living tissue has been supposed to be a factor in the softening and destruction of lung tissue by tubercle; and, on the other hand, an abundant supply of silica in the blood has been supposed to aid in the formation of fibroid or cicatricial tissue. The subject has been worked at by Kobert, Siegfried, Ott,[7] von Weismayr,[8] Weicker, Schulz, and Rohden.[9] Their results look promising.

[Table

| | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | Total Solids. | Sulphate of Lime. | Carbonate of Lime. | $CO_2$ c.cm. | Other Constituents. |
| **A. Carbonate of Lime.** | | | | | | |
| FRANCE. | | | | | | |
| *Châtel-Guyon.*—(See Alkaline Aperient Waters.) | | | | | | |
| *Pougues, Nièvre.*—Altitude 660 feet. Climate mild, equable. Indications:* digestive and urinary ailments. Season: May 15 to September 30. | St. Leger 54° | 5·5 | ... | 1·7 | 1100 | Sodium bicarb. 0·8 |
| *Chateldon,* Puy-de-Dôme.—Altitude 1130 feet. Indications: dyspepsia and urinary ailments. Used chiefly as table waters. | Puits Rond 55·7° | 2·8 | ... | 1·4 | 1200 | Iron bicarb. 0·03 Sodium bicarb. 0·6 |
| GERMANY. | | | | | | |
| *Rippoldsau,* Black Forest. Altitude 2000 feet. Climate mild, but bracing, sheltered. Indications: menstrual ailments, old pelvic exudations, anæmia. Season: May 15 to September 30. | Wenzels-quelle 50° | 5·1 | 0·05 | 1·4 | 1000 | Iron bicarb. 0·12 Sodium sulph. 1·0 |
| *Driburg,* Westphalia.—Altitude 680 feet. Climate bracing, sheltered. Indications *: anæmia. hysteria, and other nervous ailments, gout and rheumatism, Season: May 15 to September 30. | Herster-quelle | 3·7 | 0·1 | 1·4 | 1000 | Iron bicarb. 0·02 |
| *Wildungen,* Waldeck. Altitude 820 feet. Climate: mild, bracing. Indications: urinary ailments, catarrh of the bladder, prostatitis, gravel, catarrh of the stomach. Season: May 1 to October 10. | Helenen-quelle 52° | ... | ... | 1·2 | 1351 | Magn. bicarb. 1·3 Sodium chlorid. 1·0 Iron bicarb. 0·018 Silica 0·03 |

* The indications throughout this table are those established by custom.

| | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | Total Solids. | Sulphate of Lime. | Carbonate of Lime. | $CO_2$ c.cm. | Other Constituents. |
| **B. Sulphate of Lime.** | | | | | | |
| ENGLAND. | | | | | | |
| *Bath*, Somerset.—Climate mild. Indications: gout, rheumatism, rheumatoid arthritis, sciatica, vesical catarrh. Season: all the year round, but especially from May to October. | King's Bath 104°-119° | 2·0 | 1·1 | 0·14 | 24-95 | Radium and helium also present. Strutt has estimated that the quantity of radium annually delivered by the Bath spring is about $\frac{1}{5}$ of a gramme.[10] |
| FRANCE. | | | | | | |
| *Vittel*, Vosges.—Altitude 1110 feet. Climate mild, variable. Indications: arthritis, urinary and bilious affections (de la Harpe, 224). Season: May 25 to September 25. | Source salée 52° | 2·9 | 1·4 | $CaCO_3 + MgCO_3 =$ 0·3 | 140 | Magn. sulph. 0·8 |
| | Grande Source 52° | 1·7 | 0·4 | $CaCO_3 + MgCO_3 =$ 0·2 | 100 | Magn. sulph. 0·4 |
| *Contrexéville*, Vosges.—Altitude 1055 feet. Climate mild, but variable. Indications: urinary ailments, especially gravel and cystitis. Season: June 1 to October 20. | Pavillon 52° | 2·3 | 1·1 | 0·4 | 41 | Mag. bicarb. 0·4 |
| SWITZERLAND. | | | | | | |
| *Leuk* (Louèche-les-Bains), Canton du Valais. — Altitude 4654 feet. Mountain climate, wide oscillations of temperature. Indications: chiefly skin diseases, chronic dry eczema, psoriasis, lichen, impetigo, ichthyosis, prurigo, chronic urticaria, acne, boils. Season: June to September, but especially July and August. | Saint Laurent 124·3° | 1·9 | 1·4 | $CaCO_3 +$ 0·096 | 2 | Silica 0·03 |
| *Baden*, near Zürich (See Sulphur Waters). | | | | | | |

| | Parts per thousand. | | | | | |
|---|---|---|---|---|---|---|
| | Name and Temp. (F.) of Spring. | Total Solids. | Sulphate of Lime. | Carbonate of Lime. | $CO_2$ c.cm. | Other Constituents. |
| SWITZERLAND — *continued.* | | | | | | |
| *Weissenburg*, Canton Berne.—Altitude 2880 feet. Climate mild, variable, sheltered, but rather moist from surrounding forests. Indications: Catarrhal and tubercular diseases of the lungs and air passages. Season: May 15 to September 30. | 78° | 1·39 | 1·0 | 0·039 | 1·59 | ... |
| GERMANY. | | | | | | |
| *Lippspringe*, Westphalia.—Altitude 455 feet. Climate mild and equable, rather moist. Indications: same as for Weissenburg. Season: May 15 to September 15. | Arminius 70° | 2·4 | 0·8 | 0·4 | 166 | Sodium sulphate 0·8 |

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# CHAPTER XXXIII

## MINERAL WATERS FOR INTERNAL USE

### Group B. Tonic and Reconstituent

### *II. Alterative and Nervine—Arsenical Waters*

Arsenical waters do not form a class apart. The term is applied to waters which contain a therapeutically significant amount, although usually named after some other constituent. Thus, Vichy water contains from 1 to 2 milligrammes ($\frac{1}{60}$ to $\frac{1}{30}$ grain) of arsenious acid per litre, but is known as an alkaline water. The water of Bussang is commonly called a simple aerated water, though, by virtue of its containing 2 milligrammes of arsenic per litre, it is also ranked as an arsenical water. La Bourboule, the strongest of the alkaline arsenical waters, contains as much as 28 milligrammes (nearly half a grain) of sodium arsenite per litre. Strong Levico water contains 0·0087 gramme (nearly $\frac{1}{7}$ grain), and Roncegno contains 0·15 gramme ($2\frac{1}{3}$ grains) per litre.

The toxicological action of arsenic is tolerably well known. Its therapeutical uses, though less definite, are not less real and acknowledged. But its physiological action, the mechanism of its influence in non-toxic doses, is still undetermined, and is to a large extent a matter of guesswork and speculation. Our acquaintance with its effects in poisonous amount bridges over to some small extent this gap in our knowledge.

In acute poisoning by arsenic the main symptoms are

gastro-intestinal irritation; irritation of the kidneys, shown by diminution of urine or even anuria and albuminuria; painful cramps in the limbs; cyanosis, feeble and irregular pulse, and tendency to syncope. According to circumstances, death may take place as early as five hours after the fatal dose, or it may be delayed for ten days or even more. In these subacute cases papular or pustular eruptions commonly appear from the second to the fifth day. At the same time tingling in the limbs with impairment of sensation is added, and paralytic symptoms may come on. Restlessness and insomnia supervene, and sometimes also vertigo and delirium. These nervous symptoms usually appear when the gastro-intestinal symptoms have abated or ceased. In rare cases little or no gastro-intestinal disturbance takes place; the circulation may be unaffected; and the chief symptom may be feebleness, followed by fatal somnolence.

In chronic arsenical poisoning the symptoms are nearly the same in kind, though much less marked in degree. Brouardel distinguishes four periods: (1) disturbances of the digestive system; (2) coryza, laryngeal and bronchial catarrh, cutaneous eruptions; (3) sensory disturbances, formication, and impaired sensation; (4) paralysis. It may be noticed that arsenic paralysis, unlike lead palsy, affects chiefly the lower limbs.

The common opinion that arsenic is a blood poison appears to be unfounded, and has probably arisen through confusion with arseniuretted hydrogen, which is a powerful reducing agent. Delpeuch found that the blood was not in any way altered so long as the dose remained below 0·01 ($\frac{1}{6}$ grain). When this dose was reached the result was constant: the number of the red corpuscles diminished, but in proportion to the diminution the hæmoglobin increases in the remaining corpuscles, so that the richness of the blood in colouring matter remains practically unchanged.

The influence of arsenic on nutrition has been a subject of much dispute. According to the majority of observers, small doses diminish nitrogenous excretion; large doses, on the contrary,—and here opinion is more uniform,—appear to

increase it. A point of no small difficulty to explain is the diminished combustion of fat under the administration of the drug. The supposition is that arsenic secures a more complete utilisation of food.

Giess [1] gave small doses of arsenious acid to rabbits, fowls, and young pigs. The bones of the arsenic-fed animals developed remarkably, and could be distinguished at once from those of normal animals. The arsenic-fed animals increased in body weight; but the sub-periosteal and epiphisial development of the bones was especially remarkable, the bones becoming longer and thicker.

The most remarkable fact, however, in connection with arsenic is that it is used habitually in large doses by the inhabitants of Styria, who affirm that it enables them to climb mountains with much less fatigue, increasing their strength and improving their breathing power. The drug is most commonly taken as arsenious acid at intervals of some days or more, and gradually increased till from 3 to 5 grains are taken once or twice a week.

For a long time the accounts of the arsenic eaters were received with incredulity; but the facts may now be considered as established beyond dispute. That some of the arsenic is absorbed has always been shown by its presence afterwards in the urine. The amount absorbed, however, has not yet been determined. The absorption of only a very minute proportion of the dose taken is compatible with positive results from qualitative tests applied to the urine. That only a small proportion of the dose is, as a rule, absorbed, is rendered probable by various facts. Many arsenic eaters take the insoluble orpiment or sulphide of arsenic; many others abstain from liquid when taking their dose; and cases of acute poisoning are by no means rare. In these circumstances the beneficial action of the drug may probably be ascribed, in part, at least, to an intestinal antiseptic influence, with consequent diminution of flatulence, and more effective digestion and absorption of food.

A portion of the effect in diminishing the sense of fatigue is also no doubt due to a direct action on the

nervous system. The nervous symptoms arising from toxic doses have been traced variously to inflammatory changes in the grey matter of the nerve centres, the white matter being sometimes affected, and to changes in the peripheral tracts. It is not unlikely that small doses stimulate the motor nerve centres and diminish sensibility, either by lowering the receptivity of the sensory cells or by impairing the conductivity of the sensory tracts. The matter, however, is not yet cleared up; and it is still uncertain whether a real tolerance of the absorbed drug is possible.

In obstinate cases of psoriasis, however, Hebra states that beginning with 5 milligrammes ($\frac{1}{12}$ grain) of arsenious acid twice daily, he has increased the dose until the amount taken daily reached 60 milligrammes (nearly 1 grain); and patients took this quantity for several months without intermission, losing their cutaneous disorder and not suffering any unfavourable effect. Glax,[3] when he was assistant in Körner's Clinic in Graz, was able to convince himself that arsenic eaters take as much as 0·3 to 0·4 gramme (4 to $6\frac{1}{2}$ grains) several times a week; and that real tolerance is reached. According to Besredka [2] an antitoxin is formed. The blood serum of a rabbit to which arsenic had been habitually administered when injected into another rabbit averted death from a minimum lethal dose of the drug.

In poisoning by arsenic fatty degeneration is found, affecting chiefly the liver and kidney, but involving also the glands of the stomach, the heart, and the diaphragm. Degeneration has been noticed also in the epithelium of the lungs, in the endothelium of the vessels, and in the mesenteric glands.

The formation of glycogen is arrested by toxic doses of arsenic, but does not appear to be affected by small doses. It was at one time thought that by virtue of this action the drug might be useful in diabetes. But the results have not answered the expectation; and indeed this is not surprising, since, as has been observed, arsenic attacks the vitality of the hepatic cells, on which the formation of glycogen depends.

The elimination of arsenic has also occasioned much controversy. Taylor found that its excretion by the urine might be intermittent. A. Severi[4] found that arsenic given hypodermically to dogs in such doses as to produce acute poisoning is eliminated by the urine almost wholly unchanged; the elimination, beginning immediately after the injection, is greatest during the first few hours, and continues for three or four days at most. E. Wood,[5] on the other hand, found arsenic in the urine eighty-two days after 96 drops of Fowler's solution had been taken in six days.

It is evident, therefore, that we have much still to learn before the various observations of different investigators can be harmonised, and before we understand the absorption, assimilation, and elimination of arsenic.

## Therapeutics

In mineral waters arsenic occupies a subordinate place All the arsenical waters contain other ingredients to which the chief therapeutic *rôle* can be assigned; and where arsenic is definitely indicated as a remedy, most physicians will prefer to give one of the pharmacopœial preparations. Nevertheless, in some of the alkaline and iron waters arsenic is present in sufficient quantity to be taken into account, and to determine the selection or rejection of the water according as the drug is or is not indicated.

In dyspeptic troubles due to irritability of the stomach, gastric catarrh, nervous indigestion, and hyperacidity, the value of arsenic is known to every practical physician. One or two minims of Fowler's solution before meals or from three to five minims after meals not infrequently act like a charm in such cases; and I have no doubt that the good influence of Vichy water and of Vals water in digestive ailments is partly due to the arsenic they contain.

The value of arsenic as a nerve sedative is also generally recognised, especially in asthma and in chorea. The pharmacopœial preparations are, as a rule, to be chosen here;

but when, for other reasons, a mineral water is desirable, the presence of arsenic may render it more suitable.

It is not unlikely that in diabetes arsenic may have some slight beneficial influence.

In chronic or obstinate malaria, arsenic is frequently useful, and if an alkaline water is otherwise desirable, preference should be given to one containing the drug.

In skin diseases the same rule holds good. The pharmacopoeial preparations are generally the best. The prolonged use of the drug called for in these cases renders mineral waters unsuitable as a rule.

The following table shows the strength in arsenic of some waters which, in accordance with current usage, have already been classified in other groups.

Chief Alkaline Waters Containing Arsenic.

| | Name of Spring. | Parts per thousand. |
|---|---|---|
| | | Sodium Arsen. |
| La Bourboule . . | Source Perrière | 0·028 |
| Royat . . . . | Saint-Victor | 0·004 |
| Vichy . . . . | Grand Grille, Hôpital, Célestins | 0·002 |
| Mont Dore . . . | ... | 0·001 |

Chief Iron Waters Containing Arsenic.

*A.* Carbonated Iron Waters.

| | Name of Spring. | Parts per thousand. | | | |
|---|---|---|---|---|---|
| | | Sodium Bicarb. | Iron Bicarb. | Arseniate of Iron. | $CO_2$. c.cm. |
| Bussang, Vosges . | Sce. des Demoiselles | ... | 0·0029 | 0·0012 | 500-1000 |
| Cudowa, Silesia . | Eugenquelle | 1·2 | 0·063 | 0·0026 | 1217 |

*B.* Sulphate of Iron Waters.

| | Parts per thousand. | | | |
|---|---|---|---|---|
| | Iron Sulphate. | Arsenic Acid. | Aluminium Sulphate. | Free Sulphuric Acid. |
| Vals, Sce. Louis . . | 0·39 | 0·001 | ... | ... |
| Recoaro, Civillina, Italy . | 3·2 | 0·0039 | 1·2 | 0·04 |
| Roncegno, Tyrol . . | 3·0 | 0·15 | 1·39 | ... |
| Levico, Tyrol— | | | | |
| Strong-spring . . | 4·6 | 0·006 | 0·2 | 1·6 |
| Weak-spring . . . | 0·37 | Traces | 0·004 | ... |

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## CHAPTER XXXIV

### MINERAL WATERS FOR INTERNAL USE

### Group B. Tonic and Reconstituent

### *II. Alterative and Nervine* (continued)—*Chloride of Barium Waters*

Chloride of barium was found by Braconnot in Luxeuil water. Fresenius afterwards detected it in the Kochbrunnen at Wiesbaden. Since then it has been shown to exist in minute quantity in several other waters. The Elisabethquelle at Kreuznach contains 0·064 gramme (1 grain), and the Victoriaquelle 0·089 (nearly $1\frac{1}{2}$ grains) per litre. The Llangammarch spa in Wales contains about 6 grains per gallon, or about 0·09 gramme (nearly $1\frac{1}{2}$ grains) per litre.

Chloride of barium was introduced into medicine by Dr. Crawford in 1790. He claimed great benefit from it in scrofula. Four years later Hufeland published his experience, confirming Crawford's results. He found the drug useful in all forms of scrofula, but "especially in excited and inflamed conditions (particularly of delicate and sensible parts, as of the lungs and eyes), in painful ulcers, indurations which are disposed to inflame, and cutaneous affections." [1]

After falling into complete disuse, barium has in recent years been again studied experimentally, and as a consequence has been to some extent employed in medicine. Nearly all experimental observers are agreed that it slows the

action of the heart, steadies its rhythm, and increases blood-pressure. The increased vascular tension is due, according to Kobert, to its action on the muscular coats of the vessels. Chloride of barium appears also to increase the flow of saliva.

Hare,[2] who recommends barium chloride in all forms of cardiac disease in which failure of the heart muscle is evident, gives $\frac{5}{8}$ to $1\frac{1}{4}$ grain in water three times daily. These doses are probably rather large, and $\frac{1}{8}$ to $\frac{1}{3}$ grain is a safer dose if the drug is taken for any length of time. In large doses chloride of barium is toxic. According to Bardet,[3] the lethal dose by the stomach for rabbits is 8 to 9 centigrammes per kilo of body weight, while 3 to 4 centigrammes cause toxic symptoms. In the human subject the toxicity appears to be about the same. According to Pilliet[4] and Malbec, 1 centigramme per kilo body-weight administered hypodermically proved fatal to dogs.

The disuse into which this drug has fallen was probably due, in part at least, to the large doses that were formerly employed. The amount taken daily was commonly raised from 1 or 2 grains to 15 or even 30 grains.

A mineral water which happens to contain chloride of barium in large enough quantity is an excellent vehicle for the administration of the drug. In such form the risk of decomposing it by other chemicals is avoided.

The Llangammarch waters have been used with benefit in cardiac cases. How far the good effects may be due to the chloride of barium, how far to carbonic acid baths of the Nauheim type, and how far to the other elements of treatment, is not an easy matter to determine.

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# CHAPTER XXXV

## THE WHEY CURE AND THE GRAPE CURE

WHEY is the liquid remaining after the separation of the butter and casein from milk. It contains about 5 per cent of lactose or sugar of milk, and about 0·5 per cent of salts, which consist mainly of the chloride and phosphate of potassium. The lime and the iron of milk are for the most part thrown down at the same time as the casein and butter.

A collection by J. König[1] of fifty-five analyses of wheys, differently prepared, gave the following mean composition :—

| | |
|---|---|
| Water . . . . . . | 93·36 per cent. |
| Albuminates . . . . . | 0·85 „ |
| Fat . . . . . | 0·32 „ |
| Milk sugar . . . . . | 4·83 „ |
| Salts . . . . . . | 0·64 „ |

In eighteen specimens specially examined, lactic acid was found in amounts varying from 0·12 to 0·60 per cent. Goats' milk and whey made from it yield the following results, according to Lehmann :—[2]

| | Goats' Milk. | Whey from Goats' Milk. |
|---|---|---|
| Water . . . | 88·39 per cent. | 93·76 per cent. |
| Albuminates . . | 2·78 „ | 0·58 „ |
| Fat . . . . | 3·84 „ | 0·02 „ |
| Milk sugar . . . | 4·25 „ | 4·97 „ |
| Salts . . . . | 0·74 „ | 0·66 „ |

ASH OF GOAT'S WHEY (LEHMANN)

| | | |
|---|---|---|
| Potash | 44·58 | per cent. |
| Soda | 7·18 | ,, |
| Lime | 5·99 | ,, |
| Magnesia | 2·48 | ,, |
| Phosphoric acid | 13·78 | ,, |
| Sulphuric acid | 2·42 | ,, |
| Chlorine | 30·41 | ,, |

"The ash of whey consists, therefore, mainly of potassium chloride (49·94 per cent) and potassium phosphate (21·04 per cent)."

The quantity of whey taken daily ranges from about half a litre to a litre. In moderate doses of one quarter to half a litre it has a mild purgative and diuretic action. In large doses—a litre or more daily—it is apt to produce diarrhœa, and not infrequently gastric catarrh. Its diuretic influence, probably due for the most part to its lactose, has been found of use in cardiac dropsy. The aperient action is sometimes sought to counteract the constipating effect of some mineral waters. It is also resorted to at times in engorgement of the portal system in much the same cases as those in which the alkaline aperient waters are so useful, and over which it does not appear to show any definite advantage.

Whey has been termed "organic mineral water." Its nutritive value is so small that it may be disregarded.

Phthisis, pneumonia, and bronchitis in their chronic forms are sometimes given as indications for the whey cure; but there is not much ground for thinking it specially useful in these diseases. The districts where the whey cure is in vogue generally have the advantage of good air and of charming scenery.

The whey cure is formally contraindicated in anæmic conditions generally, as well as in chronic catarrh of the stomach or bowels.

## THE GRAPE CURE

By the grape cure is meant the daily and methodical eating of large quantities of grapes, the skins and stones

being carefully avoided. From two to four pounds is considered a small daily dose; four to six pounds a medium dose; and eight to twelve pounds a large dose.

The quantity taken at the beginning of the cure is generally from one to two pounds a day; and it is gradually increased till the full dose suitable for the patient is reached. Half the daily portion is usually taken an hour before breakfast in the morning; the remaining half in two equal portions an hour before the midday and evening meal respectively.

The composition of grape juice varies more or less according to the district. The variations are represented in the following figures per 1000 parts:[3]

| | | | |
|---|---|---|---|
| Water | 760 | to | 840 |
| Sugar | 106 | ,, | 330 |
| Free acid | 3·5 | ,, | 10·2 |
| Albumen | 5 | ,, | 20 |
| Pectin, etc. | 2·5 | ,, | 30 |
| Salts | 2 | ,, | 4 |

Grape sugar may therefore be looked on as the most important constituent.

In the moderate doses indicated, grapes are usually well borne, and promote the general nutrition. They act mildly both on the bowels and on the kidneys. In large doses they are apt to provoke diarrhœa and to cause gastric and intestinal catarrh. As a therapeutic method their value is small.

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# PART V

# THERAPEUTICS

## CHAPTER XXXVI

### THERAPEUTICS OF CLIMATE AND OF MINERAL WATERS

DISORDERS of Metabolism stand foremost amongst the ailments in which change of climate and treatment by mineral waters have gained their highest reputation. Although these therapeutic resources may not be indispensable in every case, there is no doubt that when they can be employed a satisfactory result is more readily, more agreeably, and more surely obtained than by the usual methods of home treatment. We will take in order the chief chronic disorders of tissue change.

### OBESITY

Obesity, or excessive storing up of fat, depends either on over-nourishment or on insufficient combustion of the food assimilated, or on both conditions together. Where the nourishment is in excess of the needs of the organism, its fate depends largely on its nature. In regard to nitrogenous food, the cells take up and use only what they require; the rest is cast out as refuse. But the carbohydrates and fats, if in excess and not burnt up at once in the system, are commonly stored for future use.

According to the calculations made by Rubner, Voit, and others, the food required to keep a robust man of 70 kilos in good health contains roughly 118 grammes of albumen, 56 grammes of fat, and 500 grammes of carbohydrates. These figures multiplied by the combustion value per

gramme of each kind of food yield the total number of Calories * required.

| | | | | |
|---|---|---|---|---|
| 118 grammes | (about $4\frac{1}{6}$ oz.) | of albumen | $\times$ 4·1 = | 483·8 Calories. |
| 56 ,, | ( ,, 2 oz.) | of fat | $\times$ 9·3 = | 520·8 ,, |
| 500 ,, | ( ,, 1 lb.) | of carbohydrates | $\times$ 4·1 = | 2050·0 ,, |
| | | | | 3054·6 ,, |

In this calculation allowance has been made for the imperfect combustion of nitrogenous food, the ash of such food, urea, still retaining some caloric value. When allowance is made for the food not absorbed, the net or pure combustion value of the nutrient elements is lowered still more, and is estimated by von Rechenberg,[1] as follows :—

| | | | | |
|---|---|---|---|---|
| 118 grammes | of albumen | $\times$ 3·2 = | 377·6 | pure or net Calories. |
| 56 ,, | fat | $\times$ 8·4 = | 470·4 | ,, ,, |
| 500 ,, | carbohydrates | $\times$ 3·8 = | 1900·0 | ,, ,, |
| | | | 2748·0 | ,, ,, |

The most recent careful experiments by W. O. Atwater [6] yield an intermediate value—4 Calories each for protein and for carbohydrates, and 8·9 for fats.

For a person doing little work 30 to 36 net Calories per kilo body-weight for the twenty-four hours may be regarded as a safe estimate. This would be 2100 to 2520 for a person of 70 kilos (11 stone). For very severe work the Calories might be doubled.

Recent researches by Chittenden [7] seem to show that the food requirements, especially of the nitrogenous class, may be much lower.

In many cases of obesity the fat-forming elements of the food are in excess, and at the same time there is a low combustion rate of the food elements so supplied. This low combustion rate may itself be dependent on lack of the great oxidising agency—muscular exercise—or on some obscure and ill-understood conditions.

* The unit of heat, a Calorie (with a capital), called also a large Calorie, or a kilo-calorie, is the heat necessary to raise a kilogramme of water one degree centigrade ; a small calorie (with a small c), is the heat necessary to raise one gramme of water one degree centigrade.

Anæmia is usually regarded as one cause of fatness, owing, as it is said, to the deficient supply of oxygen to burn up the oxidisable material, which consequently becomes added to the permanent store. This view, plausible as it looks, does not appear to be well founded. Contrary to the old belief that anæmia diminishes the oxidation processes, definite evidence has been furnished by Pettenkofer and Voit, by Kraus and Chvostek, and by Gürber,[2] that the amount of oxygen consumed and of carbonic acid formed is not less in anæmic conditions than in complete health. Bohland and Geppert, in fact, found the amounts greater in the anæmic; the intake of oxygen per kilo and minute being in the anæmic between 4·3 and 6·8 c.cm. of $O_2$ in comparison with the normal repose value, 3·81 c.cm. of $O_2$, and the excretion of $CO_2$ between 3·3 and 5·8 c.cm. in comparison with the normal repose value 3·08 c.cm. of $CO_2$. The increased consumption of oxygen and formation of $CO_2$ in the anæmic is no doubt explicable by the increased activity of heart and lungs to secure efficient distribution of the blood.

Various observers have thought that anæmia causes increased nitrogenous metabolism; but in the only experiments carried out with the needful control of the nitrogen in the food and in the fæces as well as in the urine there was no sign of exaggerated nitrogenous tissue change.

Indirectly, however, anæmia favours obesity through the easily induced breathlessness and sense of fatigue, with consequent lack of exercise.

We have seen that in anæmia the oxidation processes are not diminished. Another point of interest with a practical bearing is whether the oxidisation processes are diminished in the obese. To a very small extent only has this question been the subject of experiment. Von Noorden[3] made a series of observations on two fat patients in regard to the amount of oxygen consumed and carbonic acid excreted. The amounts were relatively small; but not to such an extent as to warrant the assumption of a diminished oxidising energy on the part of the cells.

According to some authors the body temperature of the obese is somewhat lower than the usual normal—according to Kisch about 0·2-0·5° C. The difference, if any, must, however, be very small.

The influence of obesity on the consumption of nitrogenous food has also been only very sparingly investigated. Probably nitrogenous metabolism is quite unaffected.

However these points may be, obesity is met with chiefly in two classes of people, commonly spoken of as the plethoric and the anæmic types respectively. The plethoric are mostly people in robust health who, though they may lead an active outdoor life, are hearty eaters, and consume more food than is required for their daily expenditure of work. The anæmic type is represented especially by young women, also occasionally by persons recovering from severe illness, such as rheumatic or typhoid fever. The obesity characteristic of middle-aged women is probably, in part at least, due to diminished muscular activity.

Some races—the Jews, for example—have a special tendency to the deposit of fat. Heredity is an important factor in the tendency to obesity, and is an unfavourable element in prognosis.

Obesity is thus evidently the outcome of many different conditions, and requires therefore to be dealt with in different ways according to its mode of origin. The fat of the robust, vigorous man will best be reduced by diminishing the food, especially the carbohydrates and fats, and increasing the amount of exercise taken. The fat of the flabby, anæmic patient is not so easily dealt with. Great care must be taken in reducing the amount of food to see that the nitrogenous elements are sufficient in amount. Not infrequently in these cases there is repugnance to meat, and the ordinary food of the patient contains too little proteid as well as too much of the carbohydrates and sometimes also of the fats. A proper adjustment of the food elements is in the first place necessary, the nitrogenous constituents often requiring to be increased actually and not merely in

proportion to the hydrocarbons and carbohydrates, which must be diminished.

Muscular exertion in these patients also requires supervision. The muscles being flabby, fatigue is easily induced, and severe exercise is apt to cause cardiac strain. In such cases, therefore, exertion should be gentle, but frequently renewed; that is to say, with frequent short intervals of rest, rather than severe, violent, or long continued. Exercises that bring all the muscles into play, like riding or rowing, are most suitable in all kinds of obesity, provided only that overstrain be avoided.

Such being the general principles in the management of obesity, can any further benefit be obtained either from climate or from mineral waters? In a large number of cases, most certainly, yes.

Let us take climate first. Those climates that cause an active demand for tissue change—climates, that is, where the heat demand is great—might be supposed to favour loss of weight. So, in fact, they do; but the increased muscular exercise taken under the stimulus of cold causes also increased appetite. The result not infrequently is that proportionately more food is taken than is necessary to replace the increased loss. In the case of robust patients, the way out of the difficulty is to avoid the overeating so apt to result from increased heartiness of appetite. In the case of flabby patients the greater amount of exercise, with the improved muscular tone consequent on it, helps to improve the character of the nutrition. The flabby fat vanishes, and the muscles grow vigorous and hard.

Mountain and seaside climates are most likely to have this result. The physiological action in both cases is in many respects identical, in spite of various points of contrast. The fresh breeze from the sea, like the cold air of the mountains, carries off the body heat, thus stimulating the muscles to exertion. The greater dryness of the air is a point in favour of the mountains, rendering increased exercise less apt to cause a sense of oppression, especially in persons who perspire freely. The opportunity for bathing

afforded by the seaside is, on the other hand, an advantage in many cases.

Now, as to the employment of mineral waters in obesity. First let us consider the use of water in baths. Sea bathing, cold baths, douches, and shower baths are beneficial, unless some distinct contraindication is present, such as a grave cardiac defect, weakness or degeneration of the heart muscle, or uncompensated valvular lesion. Carbonic acid baths and brine or sea-water are more useful as well as more agreeable than fresh water.

Regarding the internal use of water in obesity there is still much divergence of opinion. According to Oertel, water taken freely favours the laying on of fat, while the restricted ingestion of fluids has the contrary effect. According to other observers, copious water drinking is one of the most important aids in getting rid of superfluous adipose tissue.

Bidder and Schmidt[4] did not observe any increased formation of $CO_2$ in a cat after greatly increased administration of water. Loewy[5] also saw no increase in the absorption of oxygen. Experiments by various observers have failed to show that the copious ingestion of water causes any increased destruction of the nitrogenous elements of the body. All that increased water drinking does is to wash out any accumulation there may be of waste nitrogenous products in the system. The augmented removal of such bodies is speedily followed by reduced excretion, and then by the resumption of the usual level of excretion—always, be it understood, provided the ingestion of nitrogenous food has been kept strictly unchanged.

Meat in abundance induces more thirst than does a diet consisting chiefly of vegetables. No doubt also a certain amount of water or other liquid enables one to take a greater amount of food than would be the case with a dry diet. A point, however, is easily reached where increased water drinking diminishes appetite and gives rise to a feeling of satiety.

Whether abundant water drinking causes water to be

stored up in the tissues, so that they become water-logged, is a doubtful point. The question has been much discussed, and has not yet been resolved. The Munich beer drinkers, who dispose of ten or twelve or even twenty litres of beer a day, are regarded by Hoffmann as furnishing examples of water-logged muscles and heart. The obesity of such cases would consist therefore rather of water than of fat. The same condition, Hoffmann believes, is present in most cases of obesity in anæmic subjects.

In most instances the best results are obtained by restricting the amount of liquid to the lowest physiological level—between two and three pints. The attempt to diminish the amount of water below this quantity may easily lead to the retention in the system of partly-consumed nitrogenous compounds and other excrementitious products.

In dealing with a case of obesity, we must distinguish as far as possible on what causes the accumulation of fat depends, and whether the case is of the anæmic or of the plethoric type. Accordingly we must increase or cut down the amount of exercise, regulate the amount and kind of food, increase or diminish the quantity of liquid allowed, and finally determine whether mineral waters are indicated.

When the case belongs to the anæmic type, mineral waters, if used at all, must be selected with great judgment. Anything like purgation must be carefully avoided. For fat, anæmic women suffering from constipation, Elster is especially suitable, its waters containing iron in fair quantity as well as sulphate of soda. Franzensbad amongst its many springs has the same advantage in a somewhat lower degree. For the robust, Marienbad, Carlsbad, and Tarasp yield excellent results. Homburg, Kissingen, and Wiesbaden are milder in action, and to be preferred when a markedly aperient effect is undesirable.

Sea-bathing, saline, or carbonic acid baths are useful in most cases. Vapour baths and Turkish baths are sometimes employed with advantage, especially with patients of plethoric type. A visit to the Alps is beneficial in a large

proportion of cases of obesity, whether of the robust or of the anæmic type. For the robust in many cases a previous course of waters at Marienbad, Carlsbad, or Homburg is most desirable. Tarasp unites in itself the advantages of suitable mineral waters, baths, and moderate elevation. For obese patients of the anæmic type the mountains are, as a rule, much more suitable than are mineral waters. For both types of case the amount of exercise has obviously to be carefully regulated.

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# CHAPTER XXXVII

## ANÆMIA

UNDER the term anæmia many conditions of diverse origin and character are included. One point, however, they all have in common: the hæmoglobin or oxygen-carrying element of the blood is diminished. The red corpuscles are usually, but not necessarily, below, and the white corpuscles usually, but not necessarily, above the normal level in number.

Iron is the essential constituent of hæmoglobin, of which it forms 0·335 per cent. Hæmoglobin forms about 12 to 13 per cent of healthy blood; and the blood in health forms about 7·7 per cent or $\frac{1}{13}$th of the weight of the body. On this basis of calculation the blood of a person weighing ten stones would contain about 32 grains of iron. The tissues contain about half as much. The entire amount of iron, therefore, in the body of a healthy adult of ten stones would be about 50 grains or rather less. But the amount may vary considerably even in health.

Anæmic blood differs further from healthy blood in containing more water and less solid matter. The deficiency in solids falls chiefly on albumen and hæmatin. Freund and Obermayer[1] found in leukæmic blood besides albumose, peptone, which is not in healthy blood, an excess of fats and of salts, including phosphates, sulphates, and an excess of sodium, but a diminution of potash, lime, magnesia, iron, and chlorides. In pernicious anæmia and in leukæmia the alkalinity of the blood has been found to be considerably diminished; but in fifteen cases of chlorosis Gräber found normal or slightly increased alkalinity—a result confirmed

by some and contested by other observers. In addition to the wateriness of the blood the anæmic person probably has water-sodden tissues—a condition which in some cases becomes evident as puffiness or œdema.

One or two prevalent but erroneous notions about anæmia may be mentioned here. It was formerly thought that in anæmia the oxidation processes in the body were diminished; and in this supposed fact was found the explanation of the fatness so frequently observed in chlorotic girls. The researches of many observers, however, have shown that metabolism in the anæmic is practically the same as in the healthy. The respiratory exchanges are certainly not less; indeed, Bohland and Geppert found them greater than in health. Von Noorden [2] says: "The anæmic person requires and consumes at least an equal amount of $O_2$, and consequently produces the same amount of calories as the person with healthy blood." He points out that this involves a greater amount of work on the part of the individual cells in the poor blood—overwork that may cause other morbid effects.

Nitrogenous metabolism is generally considered to be increased in anæmia. This opinion has for the most part been based on urine analyses without reference to the food taken or the fæces voided, and rests, therefore, on an utterly insecure foundation. Some careful observations of Lipmann-Wulf and v. Noorden [3] seem to show that simple chronic anæmia does not impair the stability of the albuminoids in man. When morbid disintegration of protoplasm and increased excretion of nitrogen occur in anæmia gravis and in leukæmia the poverty of the blood in oxygen-carrying elements must not be held responsible; other prejudicial influences must come into play.

As a result of Dr. Hunter's admirable study, pernicious anæmia may now be regarded as a chronic infective disease of septic origin. The essential nature of other profound anæmias—leukæmia and pseudoleukæmia—is still uncertain.

The value of iron in anæmia was established before the

composition of the blood was discovered and before the metal was known to be an essential element of the red corpuscles. In many forms of anæmia the drug is a specific.

Those forms of anæmia that are due to definite and obvious causes, such as a previous severe illness, living in close and ill-ventilated rooms, deficient or bad food, and general unhygienic conditions, as a rule respond readily to treatment, including the removal of the cause and the substitution of fresh air and good food for the previous unhealthy conditions.

Essential, idiopathic, primary anæmia, or chlorosis, yields to treatment also, as a rule, but is apt to relapse. Some light is thrown on these cases by Dr. Stockman.[4] "Whereas a normal dietary was found to contain daily from $\frac{1}{11}$ to $\frac{1}{8}$ gr. of iron, the dietary of three chlorotic girls contained only from $\frac{1}{50}$ to $\frac{1}{20}$ gr. A certain amount of iron is excreted daily, and if this loss be not made up by the food, the organism gradually becomes deficient in iron and hæmoglobin; also at each menstrual period about $\frac{1}{2}$ to $1\frac{1}{2}$ grs. of iron are further lost to the body; and in the anæmic there are no reserves in the liver or elsewhere to make good this loss. The amenorrhœa so frequently seen is therefore a beneficial and protective condition."

Anæmias of another class, however,—pernicious anæmia, leukæmia, and pseudoleukæmia,—are little, if at all, influenced by iron. Arsenic has shown itself to be a valuable drug in these cases, though unable to arrest the final issue.

We have already seen (page 398) that iron is absorbed chiefly, if not wholly, in the duodenum, and iron and arsenic in mineral waters, being taken in solution and on an empty stomach, are presented in a more favourable state for absorption than are the pharmacopœial preparations as usually administered. The small quantities present in mineral waters may well have a greater effect than their rivals from the chemist. Iron in drug form acts better in large than in small doses, though, as we have seen, the amount required by the system is extremely small.

The iron waters most in vogue for the treatment of

anæmia are Schwalbach, about an hour from Wiesbaden, Spa in Belgium, and St. Moritz in Switzerland.

A great number of waters well known for other important constituents contain an amount of iron sufficient to be of use therapeutically. Bad Elster, Franzensbad, Homburg, Marienbad, Kreuznach, Tarasp, Harrogate, and others, either contain iron in their chief springs, or have separate springs containing chiefly iron. In England there are many iron springs, which share the fate of prophets in their own country. Even the excellent waters of Tunbridge Wells are comparatively little used nowadays, the absence of free carbonic acid not being atoned for by their richness in iron.

In a large number of cases, then, of simple anæmia, St. Moritz, Schwalbach, or Spa will be selected. Bad Elster or Franzensbad will receive the preference when the condition is secondary to uterine ailments, for the treatment of which these resorts are famed. Kreuznach is indicated in anæmia with scrofula; Homburg where constipation and catarrhal conditions of the bowel are present.

The question of climate is also important in anæmia. A bracing place is in all cases the most suitable. In view of the fact that an increase in the number of red corpuscles has been observed at high altitudes, such places may be expected to be useful in anæmia; and this expectation has been confirmed by experience. Anæmia frequently passes off with great rapidity in the mountains without the administration of iron in drug form, the food, no doubt, being more fully utilised, and especially the iron it contains. St. Moritz, therefore, has a great advantage in addition to its excellent waters. It must be remembered, however, that cases of very severe anæmia do not bear a high altitude well, suffering from breathlessness and anorexia. For such cases sea air is often very beneficial. The same may be said of tepid sea-baths.

Glax,[5] in his admirable *Balneotherapie*, draws attention to the value of simple change of air in anæmia, even when the new place of residence is no better, but rather worse, than the old—as, for example, from the country into the

town—ascribing the increased formation of blood to the contrasted physiological action of the different places. He has observed patients with anæmia which came on at Abbazia recover on going to another place, then, after a long residence at that place, have a fresh attack, which disappeared on returning to Abbazia—to the place, that is, where they were originally affected.

Finally, it must be observed that a few cases of anæmia, in no sense pernicious or grave, are excessively obstinate, responding only slightly to treatment, and quickly relapsing.

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2. Von Noorden, *Pathologie des Stoffwechsels*, Berlin, 1893, p. 335.
3. Lipmann-Wulf, "Ueber Eiweisszersetzung bei Chlorose," in v. Noorden's *Beitr. zur Lehre vom Stoffwechsel*, Heft i. 24, 1892 ; also Von Noorden, *op. cit.* 340-41.
4. R. Stockman, in Gibson's *Text-book of Medicine*, 1901, vol. ii. pp. 9-10.
5. Glax, *Lehrbuch der Balneotherapie*, Stuttgart, 1900, vol. ii. p. 69.

# CHAPTER XXXVIII

## PLETHORA

It has become usual to banish the expression plethora from text-books of medicine—at least in so far as the term may be taken to represent an independent pathological condition. This attitude has been adopted mainly, I believe, on account of what happens when blood is injected into the circulation, as, for example, in transfusion. If blood be thrown into the vein of an animal of the same species, the excess of plasma disappears within a day or two. The excess of red blood cells disappears also, though more slowly, and traces of the excess have been noticed as long as a month after the injection. While an increase of the blood up to 83 per cent above its normal level has not caused any abnormal condition and has not permanently raised the blood pressure, an increase up to 150 per cent endangers life by rupture of the blood-vessels. Moreover, when blood is transferred into an anæmic person the improvement is, for the most part, only temporary. Marked overfilling of the vessels causes loss of appetite and disposition to hæmorrhages from mucous membranes.

As the circulatory system so readily adjusts its size to its contents, and as the blood so quickly regains its usual level, the likelihood, or even the possibility, of a general overfilling of the vessels in ordinary circumstances has been denied. From this standpoint the condition known as plethora is ascribed simply to vaso-motor disturbances.

Such an inference goes far beyond the facts. The question is by no means such a simple affair of physics and

chemistry as is implied in the reasoning that explains away the existence of plethora.

Apart from clinical observation, the facts discovered in recent years, showing the great variations that occur in the proportion of the blood cells and in the specific gravity of the blood, would make the occurrence of plethora highly probable.

Few clinicians doubt that some persons make blood faster than others; that in some the destruction of blood outruns its formation, and that in others the formation outruns the destruction. Now that blood-letting has gone so completely out of fashion, observations bearing on the point are not within the every-day experience of medical men, as was the case with the older physicians. Blood-letting when in vogue was noticed to have a refreshing effect on plethoric patients, and frequently in the present day we hear people say they feel better after a copious nose-bleed.[1]

A case which, with others somewhat similar, I have recorded elsewhere, may be mentioned here.[2] I drew forty-eight fluid ounces of blood at one sitting from the arm of a young man of medium height, who had had at various times copious hæmorrhages from a comparatively small amount of scattered pulmonary tubercule. The patient sat up the whole time without any signs of faintness or sickness, declaring as the stream continued that he felt better and better. Only when the amount mentioned had been taken could I detect any sign of softening in the pulse, whereupon I stopped the flow. If this young man had not been suffering from plethora, in the old sense, I venture to think that the treatment would have been disastrous; whereas the benefit was immediate and lasting. The lack of such treatment had in this case already proved harmful. The home medical man had said, as I afterwards learnt, that the patient ought to be bled every six months; but was not allowed to do the needful operation, and was blamed for even suggesting it.

Whether plethora be due to excess of blood or simply to

vaso-motor disturbances, the fact remains that anything that raises blood-pressure increases the danger of hæmorrhage. For this reason the ingestion of highly aerated waters may be attended with risk if the vessels are weakened by disease. It is to be remembered also that, according to Hay, both sulphate of soda and sulphate of magnesia heighten blood-pressure. Should rupture of a blood-vessel in the brain or elsewhere appear to threaten, these aperients can hardly be considered the safest.

Apart from this occasional danger, the mineral waters containing sulphate of soda are extremely valuable in plethoric cases with tendency to constipation.

Whey cures and grape cures, as aids to enable the patient to restrict his intake of food, have been highly recommended—and with reason—in these cases.

Very plethoric people with weak arteries are better in the plains than in the high mountains.

Sea-bathing also is attended with risk for plethoric persons with degenerated vessels.

### REFERENCES

1. Compare: Samuel in Eulenburg's *Real-Encyclopädie*, 3te Auflage, 1894, Art. "Blutanomalien," Bd. iii., S. 568.
2. W. R. Huggard, "Venesection in certain Hæmorrhagic Forms of Phthisis," *Brit. Med. Journal*, Jan. 28, 1893.

# CHAPTER XXXIX

## GOUT

WITHIN recent years much light has been thrown on the nature of gout. The instructive researches of Sir William Roberts into the chemistry of uric acid combinations have made clear many points that previously were dark, and at the same time have tended to correct or to modify certain lines of treatment.

From the time when Sir A. Garrod demonstrated the presence of uric acid in the blood of a man suffering from an attack of gout, this substance has been looked on as the cause of the disease. Sir William Roberts showed that uric acid exists in the body in combination with sodium—normally as the quadriurate. The quadriurate, however, though a comparatively soluble salt, is unstable, and when circulating in any fluid rich in sodium carbonate, such as the blood, gradually takes up another atom of base and becomes converted into the biurate, a comparatively insoluble salt. The biurate exists in two forms—in an anhydrous crystalline form and in a hydrated gelatinous form, which, however, is unstable, and tends to become crystalline.

Sir William Roberts showed that sodium salts of any kind promoted the conversion of sodium quadriurate in solution into the insoluble biurate. The larger the proportion of sodium salt the more readily does the conversion occur, and the nature of the acid and the alkalinity or non-alkalinity of the medium are of no consequence. These observations have been confirmed and extended by Dr.

Luff. An "attack of gout," and the various chronic and irregular manifestations of the disease, are due, according to this doctrine, not to any poisonous influence of the noxious substance, but simply to its mechanical effect when precipitated in the tissues in the crystalline form. That uric acid is not poisonous is inferred from the absence of toxic symptoms, when as urate it has been ingested by animals, or injected into their veins; from the absence of toxic symptoms in patients immediately before the outbreak of the gouty attack, when the blood must have been saturated with the substance; and from the absence of toxic symptoms in leucocythæmia and severe anæmia, when the blood often holds an excess of uric acid in the form of quadriurate.

Sir William Roberts [1] gives a suggestive table, comparing the proportion of sodium salts in various tissues and fluids of the body, which I reproduce.

TABLE SHOWING THE PERCENTAGE OF SODIUM SALTS IN THE SEVERAL FLUIDS, TISSUES, AND ORGANS OF THE BODY

| | Sodium salts. Per cent. | | Sodium salts. Per cent. |
|---|---|---|---|
| Blood serum | 0·70 | Blood corpuscles | 0·20 |
| Lymph | 0·70 | Brain | 0·20 |
| Synovia | 0·80 | Muscle | 0·08 |
| Cartilage | 0·90 | Spleen | 0·04 |
| Fibrous tissue | 0·70 | Liver | 0·02 |

Sir William Roberts adds: "An inspection of the table shows that the tissues which are liable to uratic deposits are very much richer in sodium salts than the tissues and organs which are not thus liable." The facts just stated enable us to understand why an attack of gout should occur when uric acid salts have accumulated in the blood; but they do not show why such an accumulation should occur. No symptoms of gout appear in leucocythæmia or in anæmia, when uric acid is formed in abnormal amount. Why? Because in these diseases, excretion keeping pace with formation, it is speedily removed from the system, and so has not time to change from the soluble quadriurate into the insoluble biurate.

Inefficient action of the kidney seems at least one of the conditions leading up to gout. Whether in gout uric acid is manufactured in excess, and where it is manufactured—whether in the liver, or in the kidney, or in both; whether it is derived mainly from the nuclein of used-up leucocytes, or whether it is produced through defective or abnormal metabolism; whether nearly allied substances, such as caffein in tea, coffee, or cocoa, are not directly transformed into uric acid; whether the ingestion of an over-abundance of nitrogenous food, especially of meat, increases the formation of it—these are questions on which as yet there is no unanimity of opinion. From a practical point of view the issues that turn on the foregoing considerations have happily been for the most part settled empirically.

The healthy action of the kidneys and of the liver is important both for the avoidance of an attack of gout and for its removal when in progress. Articles of food containing nuclein—such for example as liver, sweetbread, meat extracts, and soup—should be withdrawn. Coffee, tea, and cocoa are best avoided, or taken very moderately if at all. Meat should be only sparingly admitted. Eggs, milk, and cheese being free from nuclein, or rather from purin bases or xanthin bodies, may safely be called on to furnish the needful amount of proteid food.

Any carbohydrates that are found to cause acidity—and these are not always the same for every patient—should be rejected. Alcohol is dangerous in any but the smallest quantities, probably owing to its diminishing the functional activity of the liver or of the kidneys.

Luff's [2] interesting experiments yield the remarkable result that, though the ash of vegetables increases the solubility of sodium biurate, an artificially prepared ash of the same constituents has not this effect. Luff also showed that acids, and the diminution of blood acidity, do not diminish the solvent power of blood serum for sodium biurate. He confirmed also Roberts's view that alkalinity as such has no solvent effect. The practical outcome of his experiments is that the gouty patient should adopt mainly a vegetable diet.

How far do mineral waters help in the treatment of gout? Let us look at the indications. The indications are: to diminish the formation or production of uric acid; to increase its solubility; to hasten the removal of uric acid salts as formed; to cause resolution and removal of sodium biurate already deposited in the tissues; to secure the most thorough removal of all effete products from the system, such products being harmful probably by diminishing the functional activity of the excreting organs; to keep digestion, stomachic and intestinal, in good order, for it cannot be a matter of indifference whether the products of digestion are those normally formed or are the result of fermentative or putrefactive changes, whereby the organism would not merely be defrauded of its rightful pabulum, but would be exposed to the noxious influence of substances perhaps poisonous.

How far do mineral waters help to carry out the objects in view? That water in abundance is useful is obvious enough; that any salt present in the water is often injurious is also clear. Nevertheless, sodium salts may at times be beneficial, even though when introduced into the circulation they tend to hasten the formation and diminish the solubility of sodium biurate. They may improve digestion or excretion, in this way preventing the formation or hastening the removal of effete products. Thus in congested states of the liver or portal circulation Carlsbad and Tarasp waters are of signal benefit. In catarrhal and sluggish conditions of the bowels the same waters, or the waters of Kissingen, Homburg, or Marienbad serve a good purpose. Catarrhal conditions of the stomach, attended as they usually are with excessive formation of acid, are best dealt with by the alkaline waters of Bilin, Fachingen, Royat, Vals, or Vichy.

Where the pharynx, larynx, and upper air-tubes are suffering from chronic gouty catarrh, Ems and Royat have a special reputation. Skin eruptions traceable to gout are supposed to be specially benefited by the sulphur waters.

The majority of old gouty cases, suffering more or less

from uratic deposits in the joints derive most benefit from the simple or indifferent thermals. Amongst the waters having a high reputation in gout are the earthy waters of Bath and the sulphur waters of Strathpeffer in our own country, the indifferent thermals of Aix-les-Bains in France, Ragatz-Pfaeffers in Switzerland, and Gastein in Austria.

The indifferent waters are useful internally in washing out the system, though as a matter of fact they are chiefly employed externally in the form of hot baths, often supplemented by massage and movement exercises.

In the choice of mineral waters for gout the case should be regarded from a broad standpoint, the patient's general condition, his habits and peculiarities, being really of more importance than the simple fact that he has an excess of uric acid in his body. In not a few cases he may do just as well in his own house, taking four or five tumblerfuls of hot water a day, and at the same time avoiding the nuclein-containing foods. One great advantage, however, to be gained, as a rule, by a visit to a health resort is the open-air life and the avoidance of domestic and business worries—factors not to be overlooked in the causation of gout.

Climate is not without importance in gouty cases. A dry, bracing climate is always most suitable; but whether a warm or a cold climate will be most beneficial depends mainly on the peculiarities of the patient. In young, vigorous subjects a cold climate is best, tending as it does to a greater amount of out-door exercise, and consequently to increased tissue-change. In elderly and weakly subjects the same objects will be best accomplished in a temperate or warm climate.

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# CHAPTER XL

## RHEUMATISM

### Chronic Rheumatism and Rheumatoid Conditions

Various conditions are popularly included under the term "rheumatism." Here the term is applied to two classes of cases: first to chronic pain with stiffness in the joints without deformity except swelling, which occurs either as a sequel of acute or subacute rheumatic fever, or has been chronic from the outset; secondly to muscular rheumatism so-called. Rheumatoid arthritis, though differing entirely in its pathology, may also be dealt with under the same section.

As there is still much confusion in regard to these diseases, just a word or two may be said about their distinguishing features. Rheumatoid arthritis is probably a microbic disease with a foundation of faulty metabolism. Erosion and ultimate destruction of the soft parts of the joints take place with eburnation of the bone. Clinically the disease is characterised by deformity of the joints, especially of the hands, and the disease, if neglected, becomes incurable.

Chronic rheumatism resembles acute rheumatism, except in the intensity of the symptoms. It is unattended with fever, and the joints seldom show anything more than a little swelling, accompanied with stiffness and tenderness. Whether the disease is really of the same nature as acute rheumatism is not yet settled. Acute rheumatism is almost certainly due to a micro-organism, but that this is the case in chronic rheumatism, though probable, is not proved.

Muscular rheumatism or myalgia hardly deserves to be looked on as an independent disease, and painful muscular states are met with in conditions fundamentally unlike. Muscular "rheumatism" is probably allied to gout, and is most frequently met with in persons of a gouty tendency. It occurs also readily in patients suffering from articular rheumatism, but it may come on quite independently of either of these affections, from partial exposure to cold, especially after fatigue, and from other causes.

Chronic gout marked by uratic deposits in the tissues should be carefully distinguished from the affections mentioned.

These various diseases have points enough in common to make it convenient to deal with them together as regards treatment by climate and mineral waters; but the treatment in the several maladies is by no means so exactly the same that discrimination of the diseases is unnecessary.

Amongst the characteristics of these ailments is the peculiarity that they are all benefited by the external application of heat; and in fact the greatest triumphs of hot mineral waters have reference to patients suffering from various forms of "rheumatism."

We have seen that chronic gout requires copious water-drinking. In chronic rheumatism and in rheumatoid arthritis, on the contrary, copious water-drinking is seldom advisable and often harmful. While gout requires a somewhat rigid diet, rheumatoid arthritis requires "feeding up," and in chronic rheumatism no general rule can be laid down, the diet being a matter of special consideration in the individual case.

The indifferent thermals and the hot sulphur waters have the greatest reputation in these ailments. The hot saline waters, especially when charged with carbonic acid, have a much more stimulant action on the skin than have the indifferent thermals, and sometimes are to be preferred to these, when arterial or cardiac degeneration might render dangerous the degree of heat that would be necessary with the indifferent waters. Mud baths supply mechanical as

well as chemical stimulation, and thus in a still greater degree are to be preferred when a given stimulant effect is to be reached without the application of much heat. The local application of dry superheated air is useful in many of these cases.

Electric baths are valuable in rheumatoid arthritis.

The selection of a suitable health resort for "rheumatic" patients generally turns not so much on the composition of the water as on the efficiency with which the bath technique is carried out. The best results are likely to be obtained at Bath, Harrogate, Aix-les-Bains, Wiesbaden, Ragatz, and such like resorts, where the attendants are fully instructed in the most efficient method of employing their resources.

Patients suffering from rheumatoid arthritis, chronic articular rheumatism, and, as a rule, those suffering from muscular rheumatism, should be careful to select a climate that is warm as well as dry.

One of the best resorts in winter is Heluan near Cairo (16 miles)—a place which, in addition to its suitable climate, has admirable baths.

# CHAPTER XLI

## RICKETS

At one time the earthy and the salt waters were largely used in the treatment of rickets. Now that the nature of the disease has become better understood, water-drinking cures must be considered utterly worthless, though baths are not without value, and climate is an important aid to recovery.

The disease is now known to depend mainly on faults in diet, while lack of fresh air, of light, and of cleanliness strongly favour its occurrence. If suitable food is substituted for the defective diet the disease will pass off; but its disappearance will be greatly hastened by the improvement of the hygienic conditions.

The faults in diet are of various kinds. At one time the entire error was supposed to lie in an insufficient amount of the lime salts. Sometimes indeed the lime salts are not present in the food in sufficient proportion, but more frequently there is no deficiency in this respect. Most commonly children suffering from this ailment are found to have been brought up on artificial foods, for the most part farinaceous, and usually containing an abundance of the lime salts, but lacking an adequate proportion of proteid and animal fat. The nature of the error in diet must in every case be carefully inquired into, and remedied.

From Dr. Cheadle's illuminating article on the subject in Allbutt's *System of Medicine* an example is given of the influence of diet.[1] Lion cubs at the Zoological Gardens became rickety on a diet restricted to raw flesh which was

almost devoid of fat and poor in earthy salts, though rich in proteid. "The meat was that of old horses almost entirely destitute of fat, and once a week lean goat's flesh. The bones were found to be proof even against the teeth of the adult lions, and those of the cubs were powerless against them, so that the cubs got from them neither marrow, fat, nor earthy phosphates. In this case the diet was not deficient in proteid, but in fat and earthy phosphates. The history of these lion cubs is very significant; with the exception of a single litter, suckled by the dam ten years before, the cubs brought up on horseflesh in this way invariably died, the cause of death being, as invariably, extreme rickets. More than twenty litters had been lost in this way. The feeding of the last litter of lion cubs was begun in the usual fashion. The dam had very little milk, and at the end of two weeks the cubs were weaned entirely, and were then put on horseflesh as usual. They quickly became rickety, and when I saw them at this juncture the muscular weakness, as well as bone deformity, were extreme. The malady advanced rapidly and one cub died. Then, by the advice of Mr. Bland Sutton, milk, pounded bones, and cod-liver oil were added to the raw meat, which was continued exactly as before; they were kept in the same dens with the same amount of warmth and light and air, and, with the single exception of the addition to the diet, no change of any kind was made in the regimen. The change in nutrition which followed was immediate and remarkable; in three months all signs of rickets had disappeared, and the animals grew up strong and healthy—a unique event in the history of the Society."

Assuming now that a suitable diet has been established, can we quicken the restoration of health by climate or by baths?

The extreme infrequency of the disease in very warm climates, in extreme Northern latitudes, and at high altitudes, together with the greater prevalence of the disease during the winter months in temperate climates, suggest that a dry and bracing climate is the most suitable.

Amongst the most appropriate places the south coast of England and the Channel Islands answer well for the summer months. During winter Biarritz and the Riviera yield excellent results.

Massage, and warm or hot baths, especially saline, with or without a dash of cold water afterwards, are useful in the majority of cases. The facility for obtaining such forms of treatment is the main advantage of Kreuznach and similar resorts.

### REFERENCE

1. Cheadle in Allbutt's *System of Medicine*, 1897, vol. iii. p. 131.

# CHAPTER XLII

## DIABETES

DIABETES stands amongst the diseases which certain health resorts claim specially to benefit. Vichy, Carlsbad, and more recently Neuenahr, have acquired renown in large part from the improvement which diabetic patients gained there while drinking the waters.

In our sceptical time many observers have put the waters to the test in hospitals where diet could be strictly controlled. The result of such tests has generally been that no positively beneficial action on glycosuria could be detected; while in some cases the influence seemed to be unfavourable rather than otherwise.

How does the matter actually stand? How are these discrepant results to be explained?

On looking into the question we find three sets of circumstances that enable us to understand the diverse views.

In the first place, the exported waters do not represent all the hygienic and therapeutic influences brought to bear on the patient at the health resort itself—the open-air healthful life, and the freedom from the routine worries of business. Bottled Carlsbad water, for example, does not exhaust the therapeutic efficacy of Carlsbad itself.

In the next place, diabetic cases are in a large proportion of instances of a mild type, responding readily to dietetic management. In no disease in fact is the regulation of food more important than in diabetes. In no disease is it more essential to find out for each patient the

extent to which he tolerates a free diet, or needs restriction in regard to certain articles of food. In the health resorts that have gained celebrity for the treatment of diabetes—where diabetics flock for treatment—the physicians are accustomed to the strict supervision of such cases, and have indeed become specialists in the subject; while the hotels and restaurants are in the habit of providing the types of dietary prescribed.

Finally, many complications, or frequent symptoms, in diabetes—such as indigestion, gastric catarrh, and constipation—are admittedly benefited by mineral water treatment.

Apart therefore from any real efficacy of the waters, it might be expected that in many cases diabetics would return from a health resort much the better for their visit.

Have the waters then no value? and is all the benefit of treatment to be put down to the accessories? May the waters even be harmful, as some allege?

Excessive water drinking increases the amount of sugar excreted; but in the quantities in which mineral waters are usually prescribed the liquid as such cannot have any injurious effect.

What influence on the excretion of sugar then have the mineral constituents of the waters most in vogue in the treatment of diabetes? Bicarbonate of soda is the chief constituent of Vichy water; sulphate of soda, bicarbonate of soda, and common salt are the chief constituents of Carlsbad water; the bicarbonates of soda, magnesia, and lime of Neuenahr water. Homburg water contains chiefly common salt with bicarbonates of lime and iron, as does Royat in less degree, but with arsenic as well. Contrexéville water contains sulphate and bicarbonate of lime.

To none of these salts can any effect on the glycosuria be ascribed. Bicarbonate of soda is useful, however, in correcting the diminished alkalinity of the blood from which diabetics are apt to suffer, and which is one of the precursors of diabetic coma. This salt, moreover, is helpful in catarrhal states of the stomach. The same may be said of

the bicarbonates of magnesia and lime; the lime salt having the additional merit of remedying to some extent the demineralisation of the tissues, which diabetes brings in its train.

For sulphate of soda and common salt no beneficial action can be claimed, except that on deranged states of the digestive system.

Common salt may indeed, by virtue of its diuretic action and by its tendency to cause thirst, produce effects the opposite of good, sufficient to outweigh any indirect benefit it might otherwise render.

An interesting point has been raised by Glax.[1] Glax holds that the usefulness of mineral waters in diabetes depends mainly on their temperature. In diabetes the arterial tension is commonly high; and hot water drinking lowers tension. According to Glax this heightened tension is a primary element of the disease, not an effect of the presence of sugar in the blood. That the arterial tension is usually higher in the early than in the later stages of the disease is, he thinks, a point in favour of the primary origin of the condition. Plain water, taken hot, is, according to Glax, useful in two ways; it lowers tension, and by its efficacy in quenching thirst it leads to a smaller ingestion of fluid. He says, "I have placed diabetics under a treatment of this kind with ordinary drinking water at a temperature of 58° C. (136·4° F.), and found a rapid fall in the urinary excretion and the amount of sugar, with simultaneous diminution of thirst, increased activity of skin, and gain in weight."

Cold water has directly opposite effects. If these views be correct, the beneficial influence of certain waters as employed at some of the fashionable resorts for diabetics—Homburg, for example—must be represented by a minus sign.

Within recent years the treatment of diabetic patients in private hospitals or establishments for the purpose has come into vogue, especially in Germany. This plan has a great deal in its favour. The measure to which the disease

is influenced by diet, the extent of the restrictions needed, the training of the patient to substitute fats for carbohydrates in his food—these and similar advantages are more readily obtained in a special establishment than in common practice, and to a degree not possible where the medical man sees the patient only occasionally in the usual way, and where the relative supply of carbohydrates and of fats depends on the despotic will of an ordinary cook. Not merely the food and the mode of life, but the results of treatment can be exactly gauged and controlled. The training acquired in such an establishment for even a short time is of permanent value. The patient learns to take an amount of fat which he would previously have thought impossible.

What principles should guide us in determining whether a diabetic should seek change of air—whether he should undergo a course of mineral water treatment, and if so, what climate and what water are most suitable?

The first and most obvious principle is that no really bad case should be sent abroad. Not merely will no benefit be gained, but great risk of coma will be incurred owing to the inevitable fatigues of travelling. Even cases of this kind, however, may obtain at least temporary benefit by the dietetic and hygienic régime of a well-managed establishment for the purpose—if such be readily available.

In regard to the milder cases, while a dry climate should always be selected, as it enables the patient to spend more time out of doors without risk, the choice between a warm and a cold climate will be determined according to general principles. The choice depends on the patient's general condition, his capacity for exercise, and his power of resisting cold. Some patients cannot stand cold, others cannot stand heat. In each case the individual peculiarities must be weighed. But above all it must be remembered that suitable food is more important than climate or mineral waters. Unfortunately few places, except some of the well-known summer mineral-water resorts, lay themselves out to cater for diabetics. The mental element must also

be borne in mind, and patients should be sent only to a place where the surroundings are likely to be congenial and cheerful. Anxiety and other depressing emotions react most unfavourably on these invalids.

The places chiefly in vogue for diabetes are Carlsbad, Neuenahr, and Vichy. Marienbad, Homburg, Tarasp, Contrexéville, Vals, Royat, and others are also visited by patients of this class to a much smaller extent.

As mineral waters are useful in diabetes, mainly in an indirect way, through removing complications, such as the various disorders of the digestive system, the most appropriate water will be the one most suitable for the particular disturbance the patient may have. Gastric catarrh without constipation may be sent to Neuenahr, Vichy, Vals, or Royat. Gastric catarrh with constipation will be likely to derive benefit from Carlsbad, Marienbad, or Homburg.

The arsenic in the waters of Vichy, the arsenic and iron in Royat, may in some instances determine a preference.

### REFERENCE

1. Glax, *Lehrbuch der Balneotherapie*, 1897, vol. i. p. 56.

# CHAPTER XLIII

## SYPHILIS

Syphilis is one of the diseases for the treatment of which certain resorts have acquired a special reputation. Amongst these Aix-la-Chapelle or Aachen in Germany, Schinznach in Switzerland, Luchon, Cauterets, and Barèges in France, are particularly well known. The chief merit of these stations lies in the completeness of the arrangements for mercurial treatment. Aix-la-Chapelle or Aachen especially is distinguished in this respect.

Formerly sulphur waters were supposed to render mercurial treatment more efficacious or more easily borne—a claim that cannot be substantiated and is now rarely heard.

Apart from specific treatment, the cachexia following syphilis or the indiscreet use of remedies may be benefited by thermal baths or by bracing air, in accordance with the general principles already laid down.

## CHAPTER XLIV

### TUBERCULOSIS *

THAT climate is not without importance in the treatment of phthisis is made evident by the improvement or deterioration that takes place in a large proportion of cases directly after a change of air. Now this might be ascribed to other influences, were it not for the fact that the improvement or deterioration is, as a rule, exactly as foreseen. Not an uncommon experience of mine is for a patient to come up to Davos contrary to medical advice, to lose ground there, and directly on being sent down to a suitable place in the lowlands to make rapid strides ahead. Or the case may be reversed. A young and comparatively vigorous patient, sent to a warm climate, fares badly there, and speedily gains ground on coming to the mountains. Instances of this kind are too frequent in my experience, and I am sure in the experience of all who have had the opportunity of observation, to permit of doubt as to the benefit to be gained from a suitably chosen climate in pulmonary tuberculosis.

The first point to recognise is that there is no *one* best climate for all cases. No climate has a monopoly of good effect. For every climate, too, there are unsuitable cases. In some instances climate is of comparatively little importance. That is to say, the patient will do well in any fairly good climate where he follows a suitable mode of life.

* Some of the following observations were contributed, in the first instance, to the discussion on Climate at the British Congress on Tuberculosis, 1901.

It is possible to select climate on wrong principles—to make the decision turn on points which, though important enough in themselves, are quite irrelevant for the purpose. The points that I specially mean are the presence or absence of a cavity and the duration of the disease—whether the disease is incipient or of long standing. Important as these considerations are in reference to prognosis, in reference to climate they are really irrelevant.

Now what principles have we to guide us in the selection of climate for patients suffering from tuberculosis? The principles are simple enough, but the application of the principles will afford scope for the exercise of the utmost acumen and judgment. The problem is a threefold one. We must know the physiological or therapeutical action of the climates at our disposal; we must estimate the factors that determine the reaction or response of the patient to the various climatic influences, of which the chief is the demand for heat production; and we must decide on the correspondence or fitness, the relation between the patient before us and the climate we select.

Each of these aspects of the question may be looked at from a standpoint giving a broad view.

In regard to climate therapeutically, the most fundamental point is its action on tissue change; and its action on tissue change depends on its heat-abstracting powers. Now, the heat-abstracting qualities depend not on temperature alone, but on temperature in combination with the humidity of the air, relative and absolute, and the amount of wind. Climates can, therefore, be best arranged in series according to their physiological action. At one end of the series stand those climates whose heat demands are large; at the other end those climates whose heat demands are small. These climates may be subdivided according as the heat demand is regular or irregular in its variations. In warm climates the amount of moisture, especially the relative humidity, is the chief circumstance determining the regularity of heat demand. If the relative humidity be high, when the temperature falls a few degrees the water-

vapour in cooling becomes a sort of sponge to absorb heat from the body, radiation and evaporation at the same time being hindered. While heat is thus removed by the cooled water-vapour, the degree of cold may be insufficient to cause either the contraction of the surface vessels which would protect the inner organs, or such a response on the part of the organism as would lead to a more rapid development of heat.

In cold climates, on the contrary, the condition determining regularity in heat demand is the absence of wind, the humidity of the air, relative or absolute, being then of little importance. The amount of moisture is small even at saturation point. Further lowering of temperature, therefore, does not cause the chilly sensation that would occur from a similar fall in warm air of a like degree of relative humidity. Cold air — air below the freezing-point of water—may, even when saturated with moisture, be regarded as dry in reference to the human body. But at such a temperature the slightest movement of the air greatly increases the demand for heat production. Equable climates are of necessity rather humid; and hence are amongst the most irregular and variable in their heat demands. Dry climates are never equable in temperature, though they may be regular—I do not say equable—in their heat demands.

High altitudes come into the group of climates having a demand for a high rate of tissue change. The hæmopoietic influence of high altitude is a favouring circumstance in the same direction.

Now let us look at the next aspect of the problem—the estimate of the patient's power of response to the demand for an altered degree of tissue change. The fundamental principle may be laid down that the best climate for a person is that where nutrition is at the highest level; and nutrition is at its highest level where the demand for tissue change—the demand for the production of heat—best coincides with the patient's power of response. The same climatic conditions do not act on all people alike. The

response to heat and to cold differs enormously in different people. Patients may be classified according to their vitality or general vigour or power of resistance to cold. Whether a climate is bracing or relaxing or depressing depends mainly on the patient's power of response.

How is this power of response on the part of the patient to be determined? Apart from direct inquiry as to how the patient bears heat and cold, an examination of the muscular system and of the organic functions generally will enable us, in the large majority of instances, to come to a right conclusion. In some cases the point can be settled only by trial. Young people still in the period of growth usually respond well to a climatic demand for a high rate of heat production. The contrary is the case with old people as a rule.

In regard to the remaining aspect of the problem—the fitness of different classes of patients for different types of climate—certain prominent symptoms are of importance, though of importance quite subordinate in value to the broad principle just laid down.

The cold, dry climate characteristic of the Alpine resorts is suitable for persons of robust constitution apart from their local disease; also for persons, though not robust, whose organs of nutrition and oxidation are sufficiently sound functionally to do much more work than they have been accustomed to at home. The lungs may be extensively damaged, but yet have reserve enough to respond easily to the increased demand.

Persons, on the contrary, of feeble circulation, with low digestive and assimilative powers, with small lung capacity, even though there may be but little damage present, will fail to respond to the cold, and so far from finding the climate bracing, will find it depressing in the extreme.

No stress whatever is to be laid upon the duration, extent, or stage of the disease pathologically. These considerations, though important from other points of view, are of little value in the selection of climate. Pyrexia, on the other hand, is always an important consideration in

regard to climate. Generally a patient with much rise of temperature will be well advised not to undertake any long journey until the disease reaches a less active stage, even though at the end of his journey he should be in a more suitable climate.

The cases that get on well in the uplands of South Africa are in the main of the same character as those suitable for the Alps. A feverish tendency, however, may be considered to render a patient quite unfit for South Africa. Sub-acute cases, which commonly do well in the Alps, are thus practically excluded.

The innumerable high-lying resorts of the Rocky Mountains, of which Colorado Springs and Denver are the best known, answer well for the same class of cases as those indicated for the Alps and for the South African highlands. The American mountains are colder than the South African, and less cold than the Alpine resorts. They are more suitable for patients of low vitality than are the Alpine regions.

Wind and dust are amongst the chief drawbacks of nearly all American health resorts, and especially of those in the Rocky Mountains. The South African highlands suffer from the same plague. The Alpine resorts, owing to their covering of snow, are entirely free from dust during the winter; and in every case their comparatively sheltered position has been one of the factors that have led to their development.

One feature common to these three elevated regions—the Alps, the South African plateau, and the Rocky Mountains—is that the climate is a strong inducement to an open-air life.

The Mediterranean coast of France and of North Italy is marked by a much greater degree of warmth and of dryness during the winter season than might be expected from its geographical position. The winter temperature is, roughly, about ten degrees higher on the Riviera than on the south coast of England.

The Riviera is suitable for a very large class of invalids

who have not vigour enough to respond to the cold of the Alps. Old people especially, with tendency to bronchial catarrh, do well.

Egypt, though warmer and drier than the Riviera, may practically be considered suitable for the same class of cases.

The winter climate of the Canary Islands resembles in many respects that of the Riviera; but it is not so dry. It is suitable for the same class of cases—cases of not very active disease in persons of somewhat low vitality.

Madeira has a much less dry climate than any of the places mentioned. Though it has lost its former popularity, it is still useful for many patients of a low grade of vitality, and especially for persons with renal complications.

The English south coast affords the most suitable winter quarters for many invalids. Bournemouth and Ventnor have deservedly been favourites for many years. Cases with serious digestive troubles and with tendency to diarrhœa do better there as a rule than at the Continental resorts. Persons in fairly good general health, with chronic disease not in a very active condition, not infrequently get on better on the south coast of England than elsewhere.

A word or two may be said touching leading symptoms in regard to the choice of a resort.

A high degree of fever, 102° F. in the afternoon, generally means that for the time being absolute rest is indicated; and a journey, especially to a foreign or distant health resort ought as a rule to be postponed till a less active condition is reached. A normal or subnormal temperature in the morning and a temperature of about 102° F. in the afternoon are not necessarily a contra-indication either to travelling or to the selection of an Alpine or of a Mediterranean resort. But in such a case the medical adviser should be very sure of his ground before he counsels such a step. A temperature over the normal in the morning, say 99° to 100° F., and reaching 101° or 102° F. in the afternoon, is usually best treated by rest at home rather than by change of climate.

In regard to hæmoptysis a distinction has to be drawn between the hæmorrhages of early phthisis (usually small) and the hæmorrhages from large cavities in the advanced disease (usually copious). The early hæmorrhages get on well in any climate that suits the patient otherwise; hence the hæmorrhage need not be specially considered in making a selection. Cases of this kind with only slightly marked physical signs, as a rule, do remarkably well in the mountains. Hæmorrhages from large cavities, on the contrary, usually show a greater tendency to recurrence at a high altitude than at a low level. The seaside is popularly regarded as predisposing to hæmorrhages, but the tendency is probably an individual one.

A patient affected with tubercular* disease of the intestines or with a marked tendency to diarrhœa will in most cases do wisely to remain in England; Madeira and the Canary Islands are especially to be avoided.

Irritable and inflammatory conditions of the pharynx and larynx are apt to be made worse by an excessively dry atmosphere. Such cases, for example, are apt to suffer much more discomfort at Davos than at Bournemouth. Tubercular ulceration of the larynx, however, without much surrounding inflammation or irritation — and this is a frequent condition—does well in Davos, provided the case is otherwise suitable. So much depends on local treatment and absolute rest for the voice in cases of tubercular laryngitis that patients should be under the close observa-

* Concerning the distinction between "tubercular" and that much abused word "tuberculous," may I quote from a letter by Dr. J. A. H. Murray to a friend of mine? "The two words differ as do *popular* of, pertaining to, of the nature of the people; *populous* abounding in people. . . . The analogy of *popular* and *populous* ought to keep you right; or that of any of the numerous pairs in -al, -ous, as, in sooth, *numeral*, *numerous*. As you know, *-al* and *-ar* are the same suffix. . . . Attention therefore to any pair in *-al*, *-ous*, will also show how to discriminate *tubercular*, *tuberculous*." *Tubercular*, therefore, is applicable both to abstract and to concrete nouns; *tuberculous* to concrete nouns only. It follows that *tubercular* is always right; while *tuberculous* must often be wrong.

Similarly, *malarial* qualifies both abstract and concrete nouns; *malarious* concrete nouns only. We may say *malarial* or *malarious country*; but only *malarial disease.*

The Latin form, *meningitis tuberculosa,* recalls the old belief that diseases are entities.

tion of a competent medical man, and as a rule in a sanatorium, where the loquacity characteristic of these patients can be kept strictly in check.

Anæmia, though a consideration to be borne in mind in the selection of climate, is of only subordinate importance unless it be extremely pronounced in degree. The slighter grades of anæmia, especially in young subjects, are usually much benefited in the mountains. Persons with extreme forms of anæmia, on the contrary, have difficulty in accommodating themselves to the smaller supply of oxygen, and may easily suffer from heart failure.

I should like to lay stress on one point. Disinfection of rooms that have been occupied by tubercular patients should be insisted on at every health resort, and medical men sending out cases would do well to satisfy themselves as to the regulations in use where the patient goes.

In conclusion, let it be said that while some margin must be allowed for error and uncertainty, attention to the principles laid down will generally enable one to make a wise choice.

Widely spread bronchial catarrh is a serious complication of pulmonary tuberculosis, and must influence our choice of climate. The first important consideration is the age of the patient. Young people—children—do best in the mountains whatever the form of the catarrh. Persons up to middle life, if fairly robust, may be sent to a cold, dry climate—to the climate of mountains if their bronchitis is attended with much secretion. If they are not robust they do better in a warm, dry climate like that of the Egyptian desert. Middle-aged people with dry irritative bronchitis or bronchitis with scanty secretion do best in a warm not very dry climate. For such cases the eastern Riviera, Orotava, and even Funchal are of use. For the more robust of this class the south or west coast stations of England are suitable. Old people with bronchial catarrh do best in a warm climate, dry or of medium humidity, according as the catarrh is dry and irritative or attended with much secretion.

Some of the favourite resorts for consumptives are suitable only during certain portions of the year. The season in the Riviera health resorts extends from November till April. The season in Egypt is shorter by almost a month both at the beginning and at the end—that is to say, it begins in December and ends in March. These limits are meant to indicate not fixed dates, but to mark roughly the period when visitors are chiefly present.

The Canary Islands, while specially suitable from November till April, have low mountain resorts to which one can retreat in the summer. Though far from being cool, they are not too hot for those who like a warm climate.

Of the Alpine resorts Davos is an all-the-year-round resort, though with two seasons: the chief season, winter, extending from the middle of October to the end of April, and the summer season, consisting of July, August, and September. The snow-melting period is sometimes supposed by persons unacquainted with the actual conditions to be unsuitable for lung patients. March is a trying month in Davos as elsewhere, not on account of the snow melting, but on account of the prevalence of wind in contrast with the stillness of the air during the winter months, and on account of the alternations in humidity. In spite of this drawback patients who are seriously ill do wisely to remain during the spring and summer months as well as during the winter, always provided that a high altitude suits them. Patients who are not seriously ill sometimes leave the mountains in March for the Riviera, and then move up to the Italian lakes in April.

## The Mental Element

In the selection of a health resort or sanatorium for consumptives the mental element in the patient deserves the most careful consideration. Worry, fretting, anxiety, or other depressing condition is an absolute bar to improvement in health. Mental excitement is hardly less prejudicial. Much of the success of the physician in charge

of consumptives depends on his grasp of the mental characteristics of his patients and his capacity for finding them suitable mental occupation. This aspect of treatment is not less important than the regulation of rest and exercise, of food, and of the general mode of life. If a patient takes an intense dislike to a place he seldom makes good progress there, and will usually be better for a change.

### Sea Voyages

Sea trips, formerly much in vogue for consumptive patients, have in recent years fallen into disfavour. They are in fact suitable for convalescent cases where all evidence of acute disease has passed away, when the patient is a good sailor, and then only when food and accommodation are far superior to what are usually procurable.

### Mineral Waters

Mineral waters are now comparatively little used in the treatment of pulmonary tuberculosis. Weissenburg in the Canton of Berne, about 3000 feet above sea-level, Lippspringe in Westphalia, and two or three other similar resorts are still visited with advantage by tubercular patients suffering from widely diffused irritative bronchial catarrh.

### The Question of Sanatorium Treatment*

There are some points in the question before us on which we are probably all agreed. There is probably no difference of opinion amongst us as to the general principles. We all think that good food and enough of it, fresh air with rest and exercise according to the patient's condition, are absolutely necessary in the treatment of pulmonary tuberculosis. We are further agreed that care is necessary

* The following observations were contributed in the first instance to the discussion of the subject at the British Congress on Tuberculosis, 1901.

to prevent the patient from becoming a source of infection to others.

Now can these objects be attained only, or best attained, in a sanatorium? Is a sanatorium the best place for every case? For some cases, yes; but certainly not for all. For all those people who are unable otherwise to secure suitable attention, hygienic arrangements, and medical supervision, a sanatorium is obviously the best place. It is also the best place for the wilful, the thoughtless, and the impulsive. The great advantage of sanatorium life is that the patient is drilled into the practice of hygiene, and his task is made easier by having fellow-learners in the same discipline. He is made to take sufficient food, to rest, and to exercise according to his condition; and he is more likely to have answered his daily prayer not to be led into temptation. In a sanatorium too the patient is under the immediate eye of his doctor; and the beginnings of new ailments are seen to at once. Patients suffering from laryngeal tuberculosis are also, as a rule, best treated in a sanatorium, where their tendency to talk too much can be kept under control.

In many cases, however, the cast-iron discipline of a sanatorium is unnecessary; in many others unavailing. Where the needful hygienic and general conditions can be secured with the intelligent co-operation of the patient, all the requirements of treatment can be carried out without recourse to the rigid system of a school. In some cases also it must be recognised that one ending only to the disease is inevitable. When this is the case little is to be gained by drilling the patient. Discipline is out of place, and, except occasionally, the thermometer does not then afford information to compensate for the anxiety or the inconvenience caused by its use.

Another consideration should weigh with us in determining whether a case would be better in a sanatorium or outside. The psychical element is important in the treatment of tuberculosis. Moping, worry, or depressing mental states of any kind have a prejudicial influence on the course of

the disease. One great object of treatment then, in most cases, will be to place the patient where there will be greatest freedom from worry, fretting, irritation, depression, or excitement. This object may or may not be best secured in a sanatorium. No general rule can be laid down; but the point should receive full attention before we decide what is best for the individual patient. A patient if happy will commonly make better progress in hygienic conditions short of the best than in ideal surroundings with worry or other depressing mental influence.

Just a word in regard to one or two points on which great stress is laid in some sanatoria: increase in weight and overfeeding. Increase in weight, though a good sign when joined with improvement in other respects, is not by itself necessarily an index of improvement, much less of recovery. In many a case the disease steadily advances when at the same time the patient is putting on weight, while cases are not infrequent in which recovery takes place though the patient remains thin.

Overfeeding, useful as it may be in some instances, certainly does harm, like overdoing anything else, when injudiciously enforced. The aim of treatment should surely be to attain the highest level of nutrition; but overfeeding by no means always secures this result.

In medicine, as in other affairs, a hobby or a system may be ridden to death; and I have not been able to assure myself that sanatoria generally are free from this tendency. A cynic once remarked that while there is a great deal of difference between a good doctor and a bad doctor, there is very little difference between a good doctor and no doctor at all. Does the same difference exist between different sanatoria?

There is a tendency on the part of some to exalt the sanatorium system, to make it appear that climate and other considerations are of little importance—that any person of ordinary intelligence can carry out the system satisfactorily. I am inclined to think, on the contrary, that the man is more important than the system. A good

man will always get good results; while the best system in the world applied zealously but without discretion will fail of its purpose. No system has yet been devised that will replace common sense. Rules are a poor substitute for principles. The conscientious and rigorous employment of any system will not atone for lack of clinical insight and for want of judgment. Is it not possible that the head of a sanatorium may lack firmness or may lack discretion—that he may not himself be gifted with a well-balanced and judicious mind? Sometimes a sensible patient might be less likely to do foolish things if left to his own judgment than if directed by a well-meaning but impulsive or injudicious autocrat.

I do not therefore think, as is now to some extent the fashion, that the whole duty of man is to send every case of phthisis to a sanatorium.

Nearly every patient would indeed be better for residence in a good sanatorium, for some time at least. A course of sanatorium treatment has much the same educational value on the grown patient as the kicking and the cudgelling a boy goes through at school, and I must confess that no patients are so easy and pleasant to deal with as those who have gone through this preliminary discipline in a sanatorium.

There are one or two points on which I think misleading ideas have gained currency. I refer to sanatorium "cures" and the comparative results of sanatorium and of outside treatment.

The term "cured" is sometimes used in rather a loose fashion. I have known the expression applied to a patient whose expectoration still contained tubercle bacilli, and had not diminished in amount. The patient had indeed gained in weight, in strength, and in general health, and was able to return to business. The term was used in this way, not by the patient, but to me personally by the medical man himself. When gently bantered on his use of the term he withdrew it, but evidently he sometimes used it in rather a misleading sense.

There is another source of error in the interpretation of sanatorium statistics. Some sanatoria will not accept severe cases. They take, in fact, only promising cases. A large percentage of recoveries obviously has not the same meaning in selected as in unselected cases. If a sanatorium has more applicants for admission than it can receive, I see no reason why it should not give the preference to those whom it thinks it can help most. The practice is perfectly legitimate, but where followed—for it is not, I believe, adopted by all sanatoria—it would modify, to some extent, our interpretation of the statistics.

Interesting statistics come from the Morgue in Paris. Vibert,[3] in looking over the register of the necropsies made at the Paris Morgue "was struck by the fact that in one hundred and thirty-one individuals of from twenty-five to fifty-five years of age, having all succumbed to violent or sudden deaths, it was noted that the existence of pulmonary tuberculosis was recognised in twenty-five, in seventeen of whom the malady was in a cretaceous or fibroid state—that is to say, of tubercles cured." In other words, the disease was present in 19·08 per cent of all cases, and in 68 per cent of those in whom it was present it was cured.

These figures, while obviously not giving a percentage of recovery in a series of cases, are valuable as showing that tubercular disease may be cured in spite of the most unfavourable circumstances.

## Scrofula and Tuberculosis of the Lymphatic Glands

Tubercle bacilli have been found in a very large proportion of chronically enlarged lymphatic glands in children; and the erroneous notion became rather widespread that all such glands are tubercular. It has been found that other bacteria such as staphylococci and streptococci will also cause chronic enlargement of the glands, which may or may not go on to suppuration.

Very many of these cases become tubercular, the lymphatic glands, the skin, or the bones getting affected.

Non-tubercular scrofulous children frequently inherit a tubercular or other morbid taint or live in unhygienic conditions. They are of various types: some coarse-skinned, pasty, and unhealthy looking; some transparent-skinned and fragile. The lymphatic glands of the neck are most frequently affected. The skin and the mucous membranes are apt to suffer from inflammations and catarrhs. Eczema of the face, thickened and irritable eyelids, nasal and pharyngeal catarrh, catarrh of the bronchial and intestinal mucous membranes,—all of these conditions, frequent in scrofulous children, readily afford an entrance to the tubercle bacillus. The teeth also are frequently bad.

The anatomical substratum of scrofula is considered by some writers to be a special vulnerability of tissue. Cornet regards it as an exaggerated permeability of tissue, especially of the skin, mucous membranes, and lymphatic channels. Micro-organisms, according to Cornet,[1] readily find their way through healthy unbroken mucous membrane. In Cornet's experiments on animals tubercular sputum, or a pure culture of tubercle bacilli placed on the sound conjunctiva, on the mucous membrane of the nose, mouth, vagina, or penis, was followed as a rule by general infection, especially when the infective material was rubbed in. Commonly the mucous membrane remained healthy; the first sign of disease being in the neighbouring glands, from which the process diffused itself over the body. Similarly the inhalation of a small amount of infective material caused tubercular disease of the bronchial glands without any sign of change in the lung itself. In one case also, out of numerous experiments on the unbroken skin, Cornet succeeded in causing tuberculosis of the lymphatic glands in the neck by rubbing tubercular material into the head of an animal, the place rubbed showing no change beyond a little scaling. In support of the view that the mucous membranes and skin are more permeable in children than in adults, Cornet cites the histological observations of Blaschko and of J. Loewy. According to these authors the epithelium of the skin in early childhood is a

honeycomb-like open network which in later life becomes closed through the growth of fresh epithelium, under the influence of external stimulation. In the female sex too the skin is, according to Cornet, more permeable than in males.

These differences are brought forward to explain the greater comparative frequency of scrofula and of tuberculosis of the lymphatic glands in children and in girls.

Some experiments on animals by Carrière[2] bear on the increased susceptibility to tuberculosis in children of tubercular parents. Carrière found that when the parent animals were injected with tubercular poisons, the offspring became more sensitive to tuberculosis. In the case of guinea pigs the receptivity to tuberculosis was at its height when both father and mother had been injected, less when the mother only, and least when the father only had been injected.

Except for the question of operation, the treatment of scrofulous glands is the same whether tubercular or non-tubercular. What scrofulous children require is to have their general health and nutrition kept up to the highest possible level. The essential conditions are good food and fresh air. A bracing climate is necessary. The teeth, if bad, should be seen to by a competent dentist. The fresh juice of raw beef is often of immense value.

In the hygienic treatment of scrofulous children three classes of health resort are in high repute: the mountains, the seaside, and saline watering-places. Of these the seaside is at present probably the most popular. Hospitals for scrofulous children have been established on the coast of nearly every country in Europe. Margate with its sea-bathing infirmary, the oldest institution of the kind, is still the chief favourite in England; and its reputation is well deserved. The whole of the east and south-east coast of England may be looked on as particularly suitable for cases of this class. In the case of children too young or too weakly for sea-bathing, sea water is used with advantage in the house, in some instances being warmed first.

The inland salt springs are also of great value when the seaside is unavailable. They lack the bracing climate of the coast; but the waters are useful, and generally yield good results. In some instances the waters are used only externally; in others they are also taken internally. Kreuznach, one of the favourite waters of this last type, contains chloride of barium and chloride of calcium, besides iron and a minute quantity of iodine. Hall, in upper Austria, Kissingen, and Soden, besides many other saline springs, are more or less resorted to by scrofulous children, especially with intestinal catarrh. In Germany there are more than thirty institutions for such children at various inland salt springs.

Eczematous conditions of the skin of the eyelids are apt to be irritated by salt water; and for these cases, as well as for chronic suppurative catarrh of the middle ear, the mountains are decidedly more suitable. The mountains are also more advantageous when bronchial or pulmonary catarrh is present; the seaside or inland saline waters, on the contrary, in cases of intestinal catarrh. Most children thrive well at high altitudes and in cold climates. Sometimes children of an extremely excitable type become more irritable and excitable in the mountains. Apart from these cases, scrofulous children may with advantage be sent to Davos, Arosa, or St. Moritz. Davos has the advantage of being an all-the-year-round resort. Moreover, it is better adapted for young children on account of the comparative absence of cold winds. The danger of infection also is infinitely less at Davos than at any other health resort visited by consumptives with which I am acquainted, owing to the stringent regulations in force concerning prophylaxis and disinfection.

In order to overcome the inherent defect of constitution, permanent residence, or at least a residence of several years in the mountains or at the seaside, is desirable. In many instances the mountains and the seaside may be visited in alternation: the seaside in summer and the mountains in winter.

## Tubercular Disease of Bones

The question of climate in tubercular bone disease is to be decided in accordance with the general principles already laid down in regard to tuberculosis of the lymphatics and of the lungs.

The surgical aspect of the case has to be considered first. The seaside or the mountains, according to the constitution of the patient, will be selected as a means of invigorating the general health.

Before sending a patient to any health resort, we should be satisfied that the medical arrangements are such as to secure suitable and efficient treatment according to the needs of the case. Patients that are very seriously ill are best off at home or in a good sanatorium. Patients seriously ill, but able to go abroad, should be sent only to places where there are proper nursing facilities for such cases.

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# CHAPTER XLV

## CHRONIC CATARRH OF THE RESPIRATORY PASSAGES

### Nasal and Pharyngeal Catarrh, Laryngitis, and Bronchitis

The catarrhal conditions of the air-tubes may be taken together. Amongst ailments of the respiratory passages, the various forms of chronic catarrh have always been considered specially amenable to treatment by climate and by mineral waters.

In regard to all these maladies, the first question from a therapeutical point of view is, Is the condition primary or secondary? If the condition is secondary — grafted on tuberculosis, syphilis, gout, or other morbid state—the fundamental affection must have our chief care.

Nasal catarrh is usually a primary affection; but chronic pharyngitis is not unfrequently to some extent at least due to gout or rheumatism, and is a common complication of syphilis and of pulmonary tuberculosis.

In all these cases the primary ailment will determine the choice of health resort. It must be borne in mind, however, that the removal of the primary ailment by no means necessarily secures the disappearance of the secondary affection, which often survives independently. This is especially the case with the chronic bronchitis that accompanies pulmonary tuberculosis, which frequently persists after the original disease has entirely healed.

For simple chronic catarrhs of the naso-pharynx, the sulphur waters are most in vogue in France; and amongst

these the springs of Eaux-Bonnes, Luchon, Cauterets, and Allevard have an excellent reputation. Mild alkaline salt waters, like those of Royat and the still milder ones of Mont Dore, are also largely used. In Germany the waters of Ems and Neuenahr are mostly employed.

In England somewhat similar results are obtained by means of mild alkaline sprays and douches.

Chronic naso-pharyngeal catarrhs are often extremely obstinate ailments, and frequently require other local treatment in addition to saline or alkaline sprays or gargles. Such sprays and gargles have merely a cleansing action. The removal of irritating secretion may in some cases be sufficient to enable the mucous membrane to recover its healthy condition, but is not sufficient to destroy pharyngeal granulations or hypertrophic tissue in the nose.

As regards climate, medium humidity is preferable to extreme dryness or extreme moisture for most chronic pharyngeal and laryngeal troubles. For hypertrophic rhinitis, on the contrary, a dry climate answers best. The absence of dust is a primary requisite for all catarrhal affections of the respiratory passages. The absence of wind is desirable in most instances, but is rarely injurious unless in conjunction with great cold or with humidity.

Patients suffering from chronic laryngitis should be sent where they will not find friends who might tempt them to break the rule of silence.

Chronic pharyngitis, though perhaps not often caused by acid dyspepsia, is usually aggravated by stomach trouble, a point that should be borne in mind in the selection of mineral waters.

Chronic bronchial catarrh, more commonly than catarrh of the upper respiratory passages, is secondary to some other ailment local or constitutional, and the line of treatment will vary accordingly.

The bronchial catarrh and the tendency "to catch cold" of young people of scrofulous habit is most likely to disappear in a dry bracing climate. For these cases the dry cold of the Alps is most suitable—far preferable, as a rule,

to the bracing but moister air of the seaside. In older cases, where much laryngeal catarrh is present, or where there is cough of an irritative character, the seaside is usually to be selected. In elderly people, as a rule, a warm climate is best; warm and of medium dryness, like the eastern Riviera or Orotava, if the secretion is scanty and the cough frequent and ineffective; warm and dry, like the western Riviera or Egypt, if expectoration is abundant and easy to get up.

Climates with great alternations in humidity and in wind are apt to make all these respiratory catarrhal troubles worse.

### Asthma

Asthma of the nervous type is a capricious ailment. The place that suits one patient often seems to provoke attacks in another patient apparently identical in every respect. All observers, however, agree that high mountain climates are most beneficial as a rule; rarely failing to diminish the frequency and the severity of the seizures, in many instances securing freedom from attack during residence, and not uncommonly permanent amelioration, even after return to the lowlands.

Oddly enough, many asthmatics find the greatest immunity from their trouble in large towns—such, for example, as London. Some asthmatics get on well at the seaside; but this is far from being the usual case.

For hay asthma the important thing is to avoid the pollen or other irritating dust that causes the trouble. The open sea or the high mountains should be sought before the usual time of attack.

### Chronic Pneumonia

For chronic pneumonic conditions the same principles hold good as for pulmonary tuberculosis. The object in view is to maintain the general health at the highest possible level, and at the same time to diminish as much as

possible all local irritation. A dry climate, free from wind and from dust is indicated, cold or warm, according to the patient's power of reaction. For young subjects the Alpine resorts offer the most favourable surroundings. For elderly subjects Egypt is preferable.

### Pleural Thickening

left by a previous exudation is often greatly benefited, and the expansion of the lung aided by residence in the mountains.

# CHAPTER XLVI

## HEART DISEASES

In cardiac ailments climate is of importance indirectly. Acute rheumatism is the most common cause of valvular disease of the heart; and this affection is considerably influenced by climatic conditions. Bronchitis and other pulmonary troubles, which are also greatly under the dominion of climate, interfere more or less with the circulation of the blood through the lungs, thus putting an additional tax on the heart.

A dry climate, not windy, is the most suitable for cardiac patients. A dry, gravelly soil should be selected; and the residence should be so placed that the patient will not have an uphill walk home.

When we see a patient suffering from cardiac symptoms we have to decide whether he should lead a more active or a less active life, whether he should change his place of residence, whether he should go away for a change of air and scene, whether he should undergo a course of baths or exercises. The decision on these points turns on many circumstances; amongst which we have to consider mainly the influence of climate, exercise, and baths. If worry has helped to bring on the symptoms, any change from the usual routine of life is likely to be useful.

Some of the general principles of treatment in chronic cardiac diseases must be borne in mind. The main objects are to strengthen the heart-muscle, and to remove hindrances whether in the pulmonary or in the general systemic circulation. The heart-muscle is benefited by improvement

in the general health and vigour. It shares in the general well-being. It is benefited also by having its work proportioned to its powers of accomplishment, which may be more or less than what it had been accustomed to.

Defects in the valves or in the orifices of the heart may be entirely compensated for by vigour in the muscle; but weakness or defect in the muscle is not remedied by perfection in the valves. Valvular disease, when present, causes few or no symptoms so long as the muscular substance is healthy and strong.

Usually, then, our first care is to strengthen the heart-walls—to avert fatigue and sudden strain. A normal tone of the arteries should be secured, as the heart works at a disadvantage when the tension is either too high or too low. Pulmonary ailments and disorders of the digestive system must, as far as possible, be relieved.

A great change of opinion has taken place within the last twenty years regarding the value of exercises and baths in the treatment of certain affections of the heart. Formerly the tendency was to diminish as much as possible the work the damaged organ had to do. Now the fact is recognised that lack of exercise of the heart, as of any other muscle, leads to weakness, and that the heart may in many cases be strengthened and its work rendered easier by suitable exercises and by baths.

The influence of exercise on heart diseases is very complex; and has been worked out from the clinical rather than from the theoretical side. Even yet the results obtained in practice could hardly be anticipated from *à priori* reasoning.

The influence of exercise varies according as the exercise is light or severe, of short or of long duration, intermittent or continuous, gradual or sudden. It varies also according to the tone or condition of the heart-muscle and of the muscular coats of the arteries.

Violent exercise, according to Leonard Hill,[1] raises arterial tension by 20 mm. Hg; this rise lasts some fifteen minutes, and is followed by a fall.

Clifford Allbutt[2] remarks that in athletic men at Cam-

bridge and elsewhere "the habitual blood-pressure ranges low." He says further: "In my own person Alpine climbing and, in later life, cycling have always been followed by a fall of blood pressure."

Concerning the increased flow of blood in the muscles during exercise Zuntz[3] says: "The dilatation of the vessels causes both a quickening of the stream and a greater quantity of blood to be contained in the active muscles. For example, J. Ranke found in the locomotor system (including the skin) of rabbits at rest 36·6 per cent of the entire amount of blood; but in the same parts of tetanised rabbits 66 per cent. . . . In any case muscular work is regularly accompanied by marked ease and increase of the blood-stream through the muscle. The facilitated flow out of the arteries must, other things being equal, bring about a fall of blood pressure in them. Hagemann and I as well as Kauffmann have in fact observed this regularly in the horse. As soon as a horse quietly standing begins to walk on the level or uphill the blood pressure falls by 10-25mm. of mercury; remains during the walk at this low level, to rise again at once when the muscles come to rest. In man as well as in the dog one sees indeed at times a quite transient fall of pressure at the beginning of work, followed by a rise of 12-25 mm. during moderate work, and by a rise of 50 or 60 mm. above the repose value during hard running or going uphill.

Lauder Brunton and Tunnicliffe[4] made some interesting experiments on the effect of resistance exercises on the circulation. They found that gentle exercise is followed by dilatation locally of the muscular arterioles with increased flow of blood through them; and generally by moderate rise of blood pressure, which, however, begins to fall during the continuance of the exercise, so that at the end of the exercise it has reached the normal. The pressure after the exercise may remain subnormal for half an hour or longer, when it gradually rises again to its initial height.

If we turn from these more or less discrepant views to the clinical side of the question we find rather less divergence in opinion.

There is pretty general agreement now that certain cardiac patients are benefited by a greater amount of exercise than they are in the habit of taking. This has been recognised from the time of Stokes,[5] whose remarks, though well known, will bear to be repeated. Speaking of the management of incipient fatty disease of the heart Stokes says: "We must train the patient gradually but steadily to the giving up of all luxurious habits. He must adopt early hours, and pursue a system of graduated muscular exercise; and it will often happen that after perseverance in this system the patient will be enabled to take an amount of exercise with pleasure and advantage, which at first was totally impossible, owing to the difficulty of breathing which followed exertion. This treatment by muscular exercise is obviously more proper in younger persons than in those advanced in life. The symptoms of debility of the heart are often removable by a regulated course of gymnastics, or by pedestrian exercise, even in mountainous countries such as Switzerland or the highlands of Scotland or Ireland. We may often observe in such persons the occurrence of what is commonly known as 'getting the second wind,'—that is to say, during the first period of the day the patient suffers from dyspnœa and palpitation to an extreme degree; but by persevering without over-exertion, or after a short rest, he can finish his day's work, and even ascend high mountains with facility. In those advanced in life, however, as has been remarked, the frequent complication with atheromatous disease of the aorta must make us more cautious in recommending the course now specified."

Cases where the heart has become weak through inactive habits in conjunction with over-eating will be dealt with best in the manner described by Stokes. But cases where the muscular substance of the heart is more seriously impaired would be hopelessly damaged by a like procedure; and in such cases the question will arise whether the light systematic exercises introduced by the brothers Schott of Nauheim should be advised or discountenanced; or whether

the saline baths of the same school are likely to prove beneficial.

What effect on the heart and circulation have these exercises and baths? In the resistance exercises there is the very lightest contraction of various muscles in turn with alternate periods of repose till nearly every group of muscles in the body has been brought into play.

The Nauheim waters employed in baths contain roughly from 1 to 3 per cent of chloride of sodium, and from 0·2 to 0·5 per cent of chloride of calcium besides free carbonic acid. The temperature is close to the indifferent point, as a rule, in the earlier baths, and later a little lower.

The effect of the baths and of the exercises is in some respects the same. By both the action of the heart is slowed and its beat becomes stronger. Dr. Bezley Thorne,[6] speaking of the baths, says: "At a time when my own pulse averaged 74 beats per minute in the recumbent, and 84 in the sitting position, the heart and vessels being sound, I found it, on four separate occasions to have fallen, within two minutes of immersion in a Sprudel bath, to from 60 to 64. In ten minutes it had risen to from 66 to 68, and there remained during the period of immersion, which in no case exceeded fifteen minutes. The exertion of dressing raised it from 76 to 78; but after the prescribed recumbent position had been assumed, it returned to from 62 to 66, with increased volume, and so remained during the period of repose. It will therefore be observed that the influence of the bath was not limited to the period of immersion."

In cases of cardiac disease with considerably impaired circulation substantially the same results are obtained. The heart acts more slowly and more vigorously, and the dilatation becomes less, a diminution of cardiac dulness of more than an inch in every direction being not uncommonly observed during the course of treatment.

Practically the same effects are generally noted from the exercises. The dilated heart shrinks; the pulse becomes slower and fuller; the breathing easier; the dusky colour

of the face clears away, and the liver, when congested, becomes smaller.

Important support to the Nauheim system is given by Saundby,[7] who employed the baths artificially prepared and the exercises in the Birmingham General Hospital. His results agree with Schott's; though his explanation is different. Dr. Allan Sturge[8] in the same number of the *British Medical Journal* gives an interesting account of his own case. After influenza he suffered from dilated heart with quick, irritable, somewhat feeble pulse. As no treatment reduced his pulse below 100 he went to Nauheim, where Dr. Schott found the apex beat to be about 2 centimetres outside the nipple line. Baths and massage were taken three days out of every four from June 15 till July 21. At the end of that time the apex beat was 1 centimetre within the nipple, the pulse 64, of good average fulness and tension. Concerning the exercises Dr. Sturge says: "The gymnastics, about which so much has been said in connection with the Nauheim treatment, were tried in my case; but they seemed to irritate the heart, and were discontinued. This was probably due to the fact that the muscles of the limbs were still, to some extent, under the influence of the rheumatism from which they had suffered, and, owing to stiffness, the resistance they offered to movement was greatly augmented, and hence the increased heart's action under gymnastic treatment."

In regard to the results generally there is a fair amount of agreement amongst different observers, though some have been unable to satisfy themselves as to the shrinking of the dilated heart. There is also a certain divergence of opinion as to the cases for which the treatment is advisable; and finally, there is a good deal of variety as to the theory or explanation of the action both of baths and of exercises.

Personally, I do not find any difficulty in accepting as a fact the rapid shrinking of the dilated heart under the influence of aerated saline baths and of light resistance exercises. The shrinking of a dilated heart under ordinary treatment is frequently witnessed by every medical man; and when the

improvement in the symptoms is rapid, the condition on which that improvement depends may be expected to be rapid also.

In regard to the cases for which the Nauheim treatment is suitable the divergence of opinion is more serious. Schott considers it suitable for all chronic cardiac ailments except advanced degenerative changes of the walls of the heart—myocarditis, arteriosclerosis, and aneurysm. Dr. Bezley Thorne employs it in arteriosclerosis and even in early stages of aneurysm. Schott considers a high degree of blood pressure as a contraindication; Grödel and Gräupner, other Nauheim practitioners, look on early arteriosclerosis as one of the most important indications for the baths.

Now, as to the explanation of the results obtained, there is much conflict of opinion.

Schott holds that the baths cause reflexly an immediate rise of cardiac force with consequently improved nutrition and muscular development. The exercises stimulate the weak heart to act more vigorously, and the increased effort strengthens the heart and promotes the circulation. A more usual view is that exercises can strengthen the heart only when it possesses a certain excess of reserve force; but that its work is eased by diminished peripheral resistance, owing to dilatation of the arteries of the skin and of the muscles, with consequent slowing of the cardiac beat and lengthening of the diastolic recuperative period. Saundby cites Marey's law that the heart beats slowly with high blood pressure and quickly with low pressure; and both his own and Schott's sphygmographic tracings are in keeping with this law. But how, then, can we say that peripheral resistance is diminished and the work of the heart lessened, seeing that the blood pressure is increased?

In Saundby's opinion the beneficial results of the Schott system depend "upon the very careful and easily regulated method by which the extra work is imposed upon the muscular wall of the heart, which is thereby developed and strengthened by systematic graduated exercises, and not by any hypothetical reflex nervous effect upon the heart."

Another explanation—which, however, rests on a basis

not yet fully proved—has been put forward by Woods Hutchinson. According to this view the muscular coat of the vessels by independent rhythmical contractions helps actively in the propulsion of the blood, especially through the smaller arteries and through the capillaries. The generally accepted view is that the heart supplies practically the entire driving force of the circulation, the function of the elastic and muscular coats of the arteries being essentially to distribute the cardiac energy most advantageously, and to regulate the blood supply to the various organs according to their temporary needs.

This doctrine of independent arterial blood propulsion is supported by arguments drawn from embryology and from comparative physiology, which can only be indicated here, but which will repay study in Woods Hutchinson's [9] interesting book.

Muscular action, so far as we are acquainted with it, is always rhythmical; and we have no knowledge of such constant tension as is usually ascribed to the muscles of the arteries. In the circulation of the lower vertebrates and of the higher invertebrates, the heart is nothing more than an aggregation of the muscular fibres of the vessels, which is not limited to one spot, but may occur in several places throughout the body. Rhythmic contraction of the vessels has been observed in the wings of the bat, in the fin of the eel, in the foot-web and in the mesentery of the frog. In many cases this rhythmic contraction "has been reported without any apparent suspicion of its real nature, as, for instance, when the arterioles of the frog are reported to seem to 'vary spontaneously'; and when, as Curtis [10] states, in watching the capillary area in a rabbit's ear, 'capillaries not noted may suddenly spring into view,' and shortly after disappear. Among mammals almost every observer has commented, with varying resultant opinions, upon the singular rhythmic contraction frequently observed in the ear of the rabbit, and occasionally in the mesentery of the same animal. Curtis admits that the capillary walls are evidently 'living cells, and possibly contractile.'" [11]

This view, if established, would afford an adequate explanation of the beneficial effects of cold water in the treatment of typhoid fever and other fevers, where the flushed skin and engorged capillaries point to paralysis of the vessel walls. The improved tone of the vessels, due to local stimulation, would thus drive on the blood, and the work of the heart would be lightened by the increased tension. The same explanation applies to the Nauheim baths. The "skin-heart" is stimulated not merely by the temperature, but by the saline constituents, and to a still greater degree by the dissolved carbonic acid.

The foregoing account very inadequately represents the force of the arguments put forward by Woods Hutchinson, who acknowledges, however, that the opinion of physiologists so far is mostly adverse.

As a matter of fact, however, there is some divergence of opinion amongst physiologists. According to Schiff, who first drew attention to the phenomenon, the rhythmic contraction of the vessels in the ear of the rabbit acts as an accessory heart. The artery, previously an extremely small red streak, fills from root to end with blood, and many very fine vessels, of which there had previously been no trace, become visible. After the dilatation has increased for a short time the vessels again become narrow, so that their lumen almost vanishes. This movement takes place, according to Schiff, from twice to eight times a minute, and the period of contraction lasts longer than the period of dilatation. According to later observers, the period of the oscillation may last from one to ten minutes.

Schiff's view that these rhythmical movements supplement the action of the heart is opposed by Aubert,[12] on account of the irregularity of the rhythm—surely not an adequate reason.

Morat and Doyon [13] reject Schiff's view on the ground that the contractions are not peristaltic, but simultaneous from one end of the vessel to the other—a statement in contradiction with Schiff's and also with Lauder Brunton's[16] account. Landois,[14] however, appears to favour Schiff's view. He says: "As the contractions of the small arteries drive the

blood more into the capillaries this movement must aid the circulation." Further he says: "Perhaps there occurs a second kind of movement in the arteries, which consists in this, that the arterial wall contracts after the passage of each pulse-wave, and thus actively pulls together the dilated vessel. This movement would correspond with the descending limb of the pulse-wave (compare the article on the 'Pulse'), and would pass on in peristaltic fashion from the large to the smaller arteries, and at the same rate as the pulse-wave—8 to 9 metres a second. This contraction wave must, in fact, immediately follow the pulse-wave (Landois)."

The Traube-Hering pulse-curves—synchronous with the respiratory oscillations in tension, but persistent after the influence of the respiratory centre and of the respiratory movements has been excluded—also point to independent contraction and dilatation of the arteries. The S. Mayer curves, which probably correspond to the rhythmic movements described by Schiff, would bear a similar interpretation.

Concerning the significance of vascular contractions, Professor Kronecker of Berne kindly writes to me as follows: "In lower animals without heart (worms), the movement of the blood takes place in general only by means of vascular contraction; and so I consider the heart, too, only as a modified portion of blood-vessel, which even in the human embryo is tubular, and in the chick (Bottazzi) contracts peristaltically.

"The vascular system can undoubtedly empty itself without the aid of the heart. This happens, indeed, after death in animals that have died quickly. When the arteries are free from blood they must already have pressed on their blood into the veins. But as the contractions of the smooth muscular fibres of the vessels take place very slowly (causing Traube oscillations in blood pressure), it cannot be admitted that a vascular contraction comes in aid of *each* cardiac pulsation."

If this theory of the active participation of the arteries in propelling the blood be established we shall have an explanation of another standing contradiction—the law con-

necting high tension with a slow pulse, and low tension with a quick pulse. According to the commonly accepted view the work of the heart is increased as the tension becomes greater; but exactly as the tension becomes greater the heart accomplishes its work more readily and more efficiently and has a longer period for repose.

Those who are further interested in the Nauheim system will do well to consult Bezley Thorne's book, where the exercises and baths are very clearly described. It has to be borne in mind, however, that the treatment is as potent for evil as for good; and that the results obtained depend mainly on the judgment and on the skill of the physician who directs, and of the operator who conducts the various processes.

### Arteriosclerosis

Under the name of arteriosclerosis several different pathological conditions are included: atheroma, the degeneration described by Gull and Sutton as arterio-capillary fibrosis, and simple hypertrophy of the muscular coat. Amongst the most common forerunners of arterial degenerations are various diseases, such as syphilis, gout, tuberculosis, or kidney disease; chronic poisoning, as with alcohol, tobacco, lead, or defective metabolism; occupations involving long-continued muscular strain or high arterial tension. Hereditary tendency is also a common factor in the causation.

According to Coats,[15] atheroma is more frequent in the aorta, especially in the arch, than in any of the other arteries—with the exception, perhaps, of the coronary and cerebral vessels—diminishing in frequency, on the whole (with these exceptions), from the larger to the smaller arteries.

Diffuse thickening or fibroid degeneration is more common in the smaller arteries.

If, then, the smaller arteries are atheromatous, probably the aorta is in the same condition; but uniform thickening of the smaller arteries does not warrant the inference that the aorta is also affected.

Much may de done by way of prophylaxis, but little by way of treatment in atheromatous conditions of the vessels. The disease may be to some extent forestalled, and its advance checked by removing or treating the causes. Syphilis should be treated; alcohol, and probably tobacco also, should be withdrawn or cut down to a minimum. Violent exercise, involving strain, should be avoided. The utmost care should be taken to secure the elimination of waste products by the bowels, kidneys, skin, and lungs.

A dry climate disposes towards exercise and favours elimination by skin and lungs. The alkaline or aperient waters are useful in correcting defects in digestion, assimilation, and the removal of waste products. Exercise should be moderate and regular; and massage may be useful in the early stages. Warm and tepid baths tend to lower arterial tension, and are employed with advantage. Grödel and Gräupner look on commencing arteriosclerosis as one of the most important indications for Nauheim baths.

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## CHAPTER XLVII

### DISEASES OF THE DIGESTIVE SYSTEM

During the last thirty years or so our knowledge of the diseases of the digestive system has been greatly enlarged. The use of the stomach tube and much experimental work have thrown light on the processes of digestion, and have led to the rational and effective treatment of ailments that had formerly proved refractory.

One result of this advance in knowledge is that the treatment of disorders of the stomach and bowels has become less and less dependent on mineral waters and on health resorts. Treatment by properly selected diet and régime, and in certain cases by washing out the stomach, and other measures, supplemented by appropriate medicines, leave a comparatively small number of cases where treatment by mineral waters or by health resorts is indispensable; though in many cases such treatment will still remain the most advisable as well as the most agreeable.

When the causes of most digestive troubles are considered, the reasons are obvious for the value of treatment at a health resort largely devoted to the management of such cases. Hasty eating, insufficient mastication, the overloading of the stomach, the abuse of alcohol, of tobacco, of tea, coffee, and condiments are amongst the most common causes of gastric catarrh and gastric neuroses. Another cause, operating in hard-working professional and business men, is active mental exertion immediately after eating. Indeed, many professional men who suffer habitually from indigestion lose their trouble the moment they start for a

holiday. In a health resort where other dietetic sinners are seeking salvation, many people can more easily lay aside their evil habits and accomplish their penance—the burden of self-denial is more easily borne in company.

The disorders of the stomach for which mineral water treatment is especially indicated are chronic catarrh, motor weakness, or atony with or without dilatation, muscular irritability and unrest, the various neuroses, such as hyperæsthesia, gastralgia, and excessive acidity.

The principles that determine the choice of mineral waters are simple. Cases marked by excessive secretion and acidity are likely to be benefited by the simple alkaline and by the aerated lime waters. In cases marked by deficient acidity or inacidity, the saline waters are indicated. When the muscular coat of the stomach is in an atonic condition, aerated waters, though for a moment stimulating, are apt to prove injurious by causing distension. The mucus formed abundantly in cases of chronic gastric catarrh is to some extent loosened and washed away by mild alkaline waters; but in many of these cases a speedier result will be obtained by washing out the stomach by means of the stomach tube. Washing out the stomach is also more efficacious in cases of dilatation than is any method of treatment by merely swallowing drugs or mineral waters, even when aided by regulation of diet.

In many disordered states of the stomach the excellent effect of a glass of plain hot water an hour before meals is well known. The addition of a pinch of bicarbonate of soda or of a little Vichy water often renders this a more efficacious abluent of the stomach walls.

The catarrhal conditions of the intestinal tract below the stomach are to a large extent amenable to treatment by mineral waters. The causes that give rise to these affections are much the same as in the case of the stomach. The mucous membrane of the duodenum and of the small intestine is irritated by fermenting lumps of unmasticated food. Flatulence, constipation, diarrhœa, or alternating

looseness and inefficient action of the bowels are amongst the most troublesome symptoms.

In catarrhal states of the small intestine mineral waters may be useful in various ways. They may help to cure a catarrh of the stomach to which the intestinal affection is secondary, the various waters being suitable according to the nature of the primary affection. Then, again, in catarrh of the small intestine, attended, as is usually the case, with diarrhœa, some waters tend to diminish peristalsis, such, for example, as the lime waters and also very small doses of Carlsbad water taken warm. In the treatment of catarrh of the small intestine, however, mineral waters occupy a subordinate place. When there is diarrhœa absolute rest in bed is called for and an unirritating diet.

In chronic catarrh of the colon habitual constipation is usually the most important element. Diarrhœa may occur without carrying off the hard masses that are frequently present. Membranous colitis is a particularly obstinate ailment, and its simulacrum, colica mucosa, a nervous ailment with perverted secretion, is only a degree less troublesome. In both one main object of treatment is to secure regular and efficient action of the bowels. For this purpose food containing a good deal of fat and a good deal of residue, as recommended by von Noorden, is in many cases probably the best kind of aperient. Boas dissents from this plan, and recommends food with little residue. Amongst mineral waters the saline group, such as those of Kissingen or of Homburg, which gently stimulate peristalsis, are more suitable than the stronger aperient waters containing sulphate of soda or sulphate of magnesia, which are apt to cause irritation of the mucous membrane. Enemeta of any sweet oil except olive oil are most useful.

Sluggishness of the bowels is sometimes overcome by aperient waters, but as a rule other means are better adapted for this purpose.

## Nervous Dyspepsia

A few words must be said about nervous dyspepsia. This ailment, first described by Leube, shows great variety in the symptoms, which are mostly referable to the stomach, but which may also proceed from the bowels. The tendency amongst later writers is to regard the affection as a form of neurasthenia, though no other manifestation of neurasthenia may be present. This view is indicated by the name neurasthenia gastrica, now in common use.

Amongst the most usual symptoms are flatulence, acidity, and eructations more or less capricious in occurrence, but influenced especially by mental states. When the mind is agreeably occupied the most indigestible articles are successfully grappled with, while in periods of depression, of anxiety or overwork, the lightest food is apt to cause discomfort.

The treatment is essentially the treatment of neurasthenia. The symptoms commonly disappear at the beginning of a holiday to return soon after work is resumed. An effort must be made to secure light, pleasant occupation after meals, and to avoid overwork. Amongst drugs arsenic and minute doses of morphia are most useful.

In the treatment of liver ailments certain mineral water resorts have always been in high repute. Carlsbad, Marienbad, Tarasp, Kissingen, Homburg, and Vichy have been amongst the chief favourites. Even with the altered views that now prevail concerning the liver and its functions, these resorts still maintain their vogue unimpaired.

Formerly when the secretion of bile was regarded as the main function of the liver, and when various drugs were credited with the power of stimulating the secretion of bile, the usefulness of the saline and alkaline aperient waters was easy to understand. Nowadays the observations of Baldi, Paschkis, Mayo Robson, and others, have shown conclusively that the salts in question do not affect the

flow of bile, unless indeed they may tend to diminish it. Water drinking is, however, usually admitted to increase the secretion.

What we now know of the functions of the liver raises our estimate of the importance of the organ in the animal economy, but considerably lowers our estimate of the importance of its secretion. The bile emulsifies fats, and so aids in their absorption; but that is probably the sum total of its service to digestion. It has but little of the antiseptic influence which formerly was ascribed to it; and whatever influence it may have can be entirely replaced by other means, as was shown in a case of Mayo Robson's, where owing to a fistula no bile reached the bowels, and yet the stools remained undistinguishable from those of a healthy person. The formation of the bile and its removal as an excrementitious product, however, have not lost their importance. Amongst the other functions of the liver is the transformation of food products. Starch, sugar, and the carbohydrates generally are converted into glycogen, to become directly available for the use of the tissues. Proteid refuse also is put into forms, urea and uric acid, in which it can be removed from the body.

Now the disorders of the liver spring mainly from over-eating, over-drinking, and insufficient exercise, very frequently in combination. In so far as these causes have been at work, the regular life and abstemious habits of a well-regulated "cure" at a health resort are likely to be most beneficial, apart from any influence the waters may have. But the waters perform also a useful function in many cases. They help to overcome constipation, with its attendant absorption of effete products into the system, and to control or get rid of gastric and duodenal catarrh, which appears in some instances to be responsible, in part at least, for catarrh of the biliary passages.

Where gall-stones are present and give rise to symptoms, removal by a surgeon will, in a large number of instances, be the proper treatment. Where this plan is not feasible, much may be done by suitable regulation of the diet and of

the mode of life. Barbera[1] shows that fats, and to a much greater extent proteids, increase the quantity of bile. Mayo Robson also calls attention to the influence of nitrogenous food. He says:[2] "It seems probable that free cholesterin in the bile passages is due in many cases to the deficiency of solvents of it in the bile, these solvents being the glycocholate and taurocholate of soda, which arise from the metabolism of nitrogenous foods. If the supply of nitrogen in the food be limited, the bile salts will be diminished and cholesterin may be precipitated. This may serve to explain the presence of gall-stones in gouty persons, who on account of the lithic diathesis limit their intake of nitrogen. The larger consumption of farinaceous food in Germany may also serve to explain the greater prevalence of gall-stones there than in England, where meat enters more extensively into the dietary. In diabetes, when nitrogenous food is prescribed, gall-stones are rarely found.'

Mineral waters, it should be clearly understood, are merely adjuncts, useful indirectly by removing adverse conditions.

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1. Quoted by Noel Paton in Schäfer's *Physiology*, vol. i. p. 566.
2. Mayo Robson in Allbutt's *System of Medicine*, vol. iv. p. 236.

# CHAPTER XLVIII

## DISEASES OF THE NERVOUS SYSTEM

### Neurasthenia

The term neurasthenia is now generally accepted as a useful designation for a large, but somewhat indefinite, class of cases characterised in various ways by lack of nerve force, not due to organic lesion or to any other functional ailment. As the manifestations of nerve force are innumerable the modes of failure are also innumerable; and some of them receive special names according to the part affected. Hence arises one subdivision of neurasthenia into cerebral, spinal, cardiac, gastro-intestinal, and sexual.

Another subdivision classifies cases according to their severity: mild cases showing only "nervousness"; medium cases constituting the bulk of the instances that seek medical aid; and severe cases bordering on incapacity to look after themselves.

From the point of view of prognosis the most important division is into cases due to overwork or other heavy nerve strain, and cases of originally low nervous endowment.

Persons of naturally robust nervous system, who chance to be hipped by overwork or worry, usually require only a little rest, with change of scene, to get back to their proper level of health. But the person of poor original endowment in the same plight lacks the needful elasticity, and is apt to remain in a condition bordering on physical bankruptcy.

There is much discrepancy of opinion as to the type of climate suitable for neurasthenia. All are agreed that rest, mental and bodily, with light, agreeable occupation, is essential. By rest is not meant simple mental vacancy or bodily inertia, though occasionally even these forms of rest may be desirable. By mental rest is intended pleasant mental occupation, with freedom from worry or exertion; by bodily rest the avoidance of exertion and especially of fatigue.

The divergence of opinion as to a suitable climate is what might be expected. An essential point always to remember is that climates are suitable or unsuitable, not for certain diseases, but for persons affected with these diseases. A person with large bones, strong muscles, and good circulation, but who at the same time is "all nerves," requires a more bracing type of climate than does a weakly person with feeble circulation who is similarly "all nerves." For a neurasthenic of the vigorous type a high altitude or bracing seaside resort will commonly help most to restore the nerves to a normal state. For the weakly neurasthenic with feeble circulation a quiet inland country place answers best; a high altitude or a bracing seaside place would be apt to cause sleeplessness and to increase the irritability.

There is, however, a good deal of caprice in the response of neurasthenic patients to the conditions of various health resorts. Glax quotes with approval Biermann's observation that some trivial accidental circumstance may determine the question whether a place agrees or not. Thus one patient finds the sight of the sea and the movement of the waves soothing influences, while another finds the shining surface of the water unpleasant and irritating to the nerves.

I cannot agree with some authors, who would lay down as a principle that neurasthenic patients support badly the scirocco, the Föhn, or the "warm wind" of the Tyrol. The mode of response of the organism to these warm winds depends on factors having no direct connection with neuras-

thenia. If the rate of combustion is such as to tax unduly the powers of the organism the warm wind affords a pleasant relief; if, on the contrary, the rate of combustion represents the best working condition of the organism, the Föhn is felt to be oppressive and irritating. The question whether a neurasthenic patient should be sent to a warm or to a cold climate turns on the broad principles already laid down. A climate should be selected that invites an open-air life. Damp cold should be avoided.

Hydrotherapeutic measures are useful in many cases and must be carefully selected when employed. The soothing forms of water treatment, such as the indifferent thermals and wet packing are the most generally useful. Sea-bathing, douches, and carbonic-acid baths have a smaller sphere of usefulness, and are adapted more especially to the robust type of patient.

### Neuralgia, Sciatica

To deal successfully with neuralgia we have to bear in mind that sometimes it depends chiefly on a general and sometimes chiefly on a local cause. Occasionally also what is called neuralgia is really neuritis. Anæmia, gout, malaria, or other toxic or depressed states of the system must be removed. At the same time all sources of local irritation must be stopped.

In the carrying out of these indications change of climate is often a valuable help. A dry, bracing place, fairly well sheltered, usually answers best. The seaside is often charged by neuralgic subjects with provoking their pains. Damp cold also disposes to the occurrence of attacks, though a dry, cold climate does not appear to be harmful, and may be beneficial in robust subjects.

Where anæmia is a factor in the case a course of iron waters, as for example at Schwalbach, followed by a stay in the high Alps, is an excellent procedure.

Inter-costal neuralgia is not infrequently due to old pleural adhesions. In these cases and in visceral neuralgia the local wet pack is generally useful.

One of the most troublesome forms of neuralgia is what is known as sciatica. Dr. William Bruce,[1] in a valuable paper analysing 418 cases, gives good reason for believing that sciatica, so-called, is really an inflammatory condition of the hip-joint; that the painful nerves are chiefly, not the sciatic nerve, but filaments from the anterior crural, the obturator, and the sacral plexus.

Whether the affection is a neuritis or an inflammation of the hip-joint, the first indication in an acute case is absolute rest. Rest in bed, or even immobilisation by means of a long splint as recommended by Weir-Mitchell for sciatica, is the most effective measure. Dr. Mitchell Clarke[2] also advocates this method. Wet-packs also are useful in subduing the inflammatory condition. Only when all inflammation has subsided are massage and exercise free from risk and likely to be beneficial.

Attention should at the same time be paid to the general measures indicated by the gouty or other morbid condition on which the arthritis depends.

## Tabes, Lateral Sclerosis, and Disseminated Sclerosis

Only in so far as syphilis may be the cause are these affections likely to be benefited by baths. And even then baths are useful only as an adjunct to specific treatment, as, for example, by inunction at Aix la Chapelle.

Baths about the indifferent thermal point, whether simple, saline, or carbonic acid, may be used without fear of doing harm, provided that no acute process is going on; but hot baths are to be avoided.

For such patients a dry climate is most desirable, and the extremes of heat and cold should be avoided.

## Migraine and Headache

Although migraine and the ordinary forms of headache are the outcome of different pathological conditions, they

have points enough in common to be treated together here. Migraine, closely allied to epilepsy and other neuroses, is often hereditary. The various forms of ordinary headache are always secondary to other morbid conditions, and these conditions tend to provoke or to exaggerate migraine in persons predisposed to it.

In the treatment of migraine the first consideration is to find out and to remove the cause. The ailment is occasionally secondary to some other morbid condition. Disorders of the digestive system are most commonly to blame. Reflex influences from a diseased womb, from a prolapsed kidney, from defect in the eye or in its muscles, represent some of the remote influences to be borne in mind.

Gout and toxic influences of the subtler sort, whether from the absorption of toxins or from defective excretion, help to bring on an attack in those predisposed to the affection.

Marcus observed in his own case that rapid oscillations in the level of the barometer were always accompanied with migraine;[3] but he ascribed the influence of climate not so much to the diminished atmospheric pressure as to changes in electrical tension.

During the prevalence of Föhn wind migraine is apt to be more frequent than at other times, as has been pointed out by various authors.

The first point then is to get the general health up to the highest level, removing as far as possible all morbid conditions. If constipation or gastric catarrh or other digestive ailment be present, the saline or alkaline aperient waters will be useful, according to the principles already laid down in regard to these ailments. The iron waters, or iron and arsenic, are useful in the anæmic conditions that are not infrequently present. As regards climate, a dry bracing place as cold as the patient can stand well is to be selected.

It need hardly be said that the regulation of the diet is of the utmost importance.

### Hypochondriasis

Hypochondriasis is essentially a mental state in which bodily sensations are dwelt on and exaggerated: the soul's heavenly light darkened by an overloaded bowel — "der Seele himmlisch Licht durch einen angefüllten Darm verdunkelt."

There may be some slight deviation from health, and that should be put right; but the important matter is to occupy the mind pleasantly. To this end pleasure resorts rather than health resorts may be useful. Cheerful companionship, the music and the manifold distractions of the gayer resorts help to draw the morbid attention away from self—thus affording the groundwork for recovery.

### Chorea

Rest and freedom from excitement are essential in the treatment of chorea, and a quiet outdoor life in the country is most suitable. In some cases, where anæmia is a marked element, Schwalbach or some other quiet place with iron waters may be useful.

Paralysis agitans is not affected by balneotherapeutic treatment or by climate.

### Epilepsy

Climate and baths have no influence on the course of epilepsy. A quiet outdoor life, free from excitement, is best for patients suffering from this ailment.

### Hysteria

In the treatment of hysteria climatic influences occupy a subordinate place. Isolation from injudicious friends, an outdoor life, and mental occupation are important elements conducive to health. Cycling and other outdoor amusements, if not carried to excess, are valuable means of treatment.

In hysterical patients of the robuster type sea-bathing and cold douches are useful. In those who are much run down in health, the first requisite is to improve the general nutrition. In such cases rest, not exercise, is usually indicated, and the Weir-Mitchell treatment is often invaluable.

### Exophthalmic Goitre
### (Parry's Disease, Graves' Disease, or Basedow's Disease)

This remarkable disease still remains to a large extent a mystery. The lesions found by some observers in the medulla and in the neighbourhood of the fourth ventricle seemed to indicate organic changes in the central nervous system as the foundation of all the symptoms; and this view harmonised with experiments tending to incriminate the restiform bodies and the corpora quadrigemina. The lesions, however, are not constant; and no microscopic alteration could be discovered in these parts *post mortem* in other cases of the disease. Changes in the lower cervical ganglion have sometimes been found; but these also are not constant.

The view that the symptoms depend on excessive activity of the thyroid has many points in its favour. An overdose of thyroid gland substance causes some of the symptoms of Graves' disease—tachycardia, for example.

Thyroid substance given in Graves' disease usually aggravates the symptoms, and has even brought on an acute attack. Proceeding on this ground, Ballet and Enriquez in 1890, and Lanz in 1894 conceived the idea of neutralising the poison with the opposite poisons produced by a thyroidless or myxœdematous animal. The first-named observers employed a serum of animals from which the thyroid had been removed; and Lanz administered the milk of a goat that had undergone this operation. The beneficial influence observed by Lanz[4] and by Möbius with serum from thyroidless animals give support to the view that the excessive activity of the thyroid is at the bottom of the mischief. The cause of this excessive activity

may then be referred to a functional disturbance either of the sympathetic or of the central nervous system.

There are many mild cases no doubt which get well of their own accord; but the severer cases, if they recover, do so only under careful management.

Worry, excitement, or mental strain is a common precursor of the disease; and the most indispensable element in treatment is to secure freedom from such influences. Fatigue, bodily and mental, should also be avoided.

As regards climatic influence a fairly bracing place is most suitable. These patients, as a rule, do not bear heat well. Suffering from excessive metabolism they have difficulty in getting rid of their heat, even by means of the moist warm skin from which they commonly suffer, and by which radiation and evaporation are increased. There is some divergence of opinion as to whether the seaside, an inland district, or a high altitude affords the most desirable residence. The fact is that patients do well in any one of the three, provided the conditions are otherwise favourable. But there seems to be a certain amount of caprice with this disease, as with asthma and with neurasthenia, in its response to climatic influence. Hence divergent opinions. Kruse praises the air of the North Sea. Möbius, on the contrary, finds that the North Sea often has an unfavourable influence, while the East Sea is beneficial. Veraguth, Bruns, and many others have seen excellent results in the high mountains. This also has been my own experience, though not invariably. Each case must be taken on its merits. Schmecks (Tátrafüred, Hohe Tátra, Hungary), 3400 feet above sea-level, has a special reputation in Basedow's disease. A sea voyage, from which some observers have seen excellent results, can be advised only where the usual discomforts of steamer travelling will not come into play.

Carbonic acid salt-baths, such as those of Nauheim and Pyrmont, have sometimes proved useful in quieting the action of the heart and in improving the general condition.

Iron when indicated can be suitably given by waters

which contain arsenic also and are free from carbonic acid, which might have an exciting influence on the heart. Roncegno and Levico waters are therefore to be preferred to those of Schwalbach.

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# CHAPTER XLIX

## DISEASES OF THE KIDNEY AND BLADDER

### Chronic Inflammations and Degenerations of the Kidney

The guiding principle in the treatment of all these affections is the same: to spare the organ needless work, while securing the efficient removal of effete products from the system. A dry climate should be selected. The Riviera and Egypt are especially suitable for the winter months, while in the summer months a dry sheltered inland district in England may be chosen.

Where granular or cirrhotic kidney depends on gout, alcohol, lead, or malaria, or is part of a general arteriosclerosis, the line of treatment indicated by the primary ailment is to be carried out. As the arterial tension in granular kidney is high, aerated mineral waters, tending as they do to increase the blood pressure, are to be avoided.

When uræmia threatens, hot-air or vapour baths are employed to produce sweating, though the extent to which the skin can act as a substitute for kidneys in removing effete products is very limited indeed. Hot or warm baths are used in similar cases, and when they cause an increased flow of urine they are decidedly beneficial.

### Pyelitis, Cystitis, Urinary Gravel and Stone

For our purpose these affections may be grouped together. When for any reason surgical treatment has to be put aside,

treatment by mineral waters is not uncommonly thought likely to afford some chance of relief.

The hope of dissolving a stone in the kidney or bladder swings to and fro, according to the view that prevails as to the power of various substances to dissolve a stone in a test glass, and as to the likelihood that such substances can be brought into efficient contact with the stone.

For a long time the presence of lime in the drinking water was thought to be to a large extent the cause of stone in the kidney or bladder, but more exact knowledge of the geographical distribution of the affection renders this view untenable. Stone is prevalent in many places where the water is comparatively free from lime, and is almost unknown in many places where the water contains much lime.

Moreover, another point to bear in mind is that stone occurs chiefly during childhood amongst the poorer classes, and in advanced life amongst the wealthier classes; and that the stone of the young, which is the most common affection, is usually composed of uric acid alone or sometimes with urate of ammonia and occasionally with urate of soda, while the stone of later life, which is comparatively rare, is generally made up of phosphates or of the oxalate of lime. Uric acid concretions are rarely found in the still-born or in the bodies of infants dying immediately after birth, but are common within the first five weeks after birth.

In Holland stone used to be extremely common, but has become much less frequent in recent times. In Ireland and in Switzerland stone is rare; but frequent in the south-eastern countries of England. According to Dr. Plowright [2] the free consumption of common salt tends to prevent the formation of uric acid calculi.

Calculi have been found always to contain an organic nucleus, such as cast-off epithelium, pus-cells, or the ova of the Bilharzia. Precipitation occurs on or in some such ground substance, which then affords a centre for further deposits.

Uric acid concretions occur in acid urine; while oxalate

of lime and the phosphates are thrown down in urine of alkaline, neutral, or slightly acid reaction.

The lime that appears in urine comes mainly from the food supplies; though when the food is deprived of lime, in starvation, and in certain pathological conditions it comes from bone tissue. The amount of lime daily used up in the system in health is not known exactly. The portion removed by the urine lies roughly between three and six grains in the twenty-four hours, and the quantity is usually increased slightly by the ingestion of soluble lime salts. The urine was supposed to be the sole channel of excretion for lime from the circulation. Now, however, lime is known to be removed from the system chiefly by the intestinal glands, especially of the lower bowel, and the amount discharged in this way is probably from four to six times as much as by the kidneys. On this supposition from twelve to thirty-six grains would be required daily to replace what is lost.

Another interesting point about lime is that it is excreted by the bowel chiefly in the form of phosphate. The administration of carbonate of lime lowers the acidity of the urine mainly by diminishing the phosphates and only very slightly by increasing the alkali.

In pyelitis and cystitis, waters containing the bicarbonate of lime, such as the waters of Wildungen or of Contrexéville, are probably more soothing than are bicarbonate of soda waters, and have a greater restraining influence on the formation of pus. Moreover, lime has the advantage of diminishing the phosphates by combining with them for excretion by the bowel, while it does not render the urine alkaline.

Oxalates may occur in the urine from the absorption of oxalates taken with food; but probably oxaluria occurs chiefly in the way shown by Dr. Helen Baldwin[1] in a research conducted in Professor Herter's laboratory in New York—that is, by gastro-intestinal fermentation of glucose with proteid. The process appears to be dependent on gastritis, and takes place only when free hydrochloric acid is absent or very much diminished.

For the treatment of oxaluria, therefore, the essential point is to cure the gastritis and to prevent the fermentation.

Where deposits tend to occur in the urine care should be taken to keep the secretion sufficiently dilute, and excessive acidity is, as a rule, best corrected by bicarbonate of lime waters.

In patients suffering from renal and bladder diseases a dry climate is best, and a medium temperature, the extremes of heat and of cold being avoided.

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# CHAPTER L

## DISEASES OF THE UTERUS AND ITS APPENDAGES

To a considerable extent disorders of the female genital system are the outcome of derangements in the general health; and, in so far as this is the case, the local trouble is likely to disappear with the cure of the general ailment. For example, amenorrhœa is often dependent on anæmia, and as the blood is restored to a healthy state the normal function returns. Even slight organic mischief will commonly pass off with improvement in the general health. Many women suffer from uterine catarrh when they are run down in general health, but lose their local trouble as soon as they have regained their usual vigorous tone. Menorrhagia, too, sometimes appears to be dependent on general flabbiness and laxity of tissue, and yields to simple general treatment. Apart from the conditions just mentioned as sources of functional disorders of the womb, habitual constipation is the most important, and to this must be added insufficient outdoor exercise.

In all these cases the chief task of the physician is to discern the underlying cause from which the local trouble springs. When the real nature of the malady has been detected the line of treatment is usually clear. Simply to label an ailment with a name by no means supplies the clue to sound management.

Where anæmia is the fundamental condition, the iron waters, such as those of Schwalbach, Pyrmont, Driberg, Cudowa, and St. Moritz, are suitable.

When digestive troubles also are present, Ems, Kissingen, Homburg, Chatel-Guyon, or Royat, may be recommended.

Cases marked by obesity or constipation are usually benefited by a course of treatment at Elster, Franzensbad, Marienbad, or Tarasp.

More serious pelvic ailments, such as old inflammatory thickenings and exudations, are not infrequently much relieved by mud baths, the warmth combined with external stimulation tending actively to promote absorption. Franzensbad, Elster, and Marienbad enjoy a special reputation for the efficacy of their mud baths in cases of this description. As they all possess iron waters, simple as well as combined with salines, they are available for the entire range of female ailments.

A word must be said touching the influence of climate on disorders of menstruation. Menstruation occurs earlier in hot than in cold climates, beginning in the Tropics at eleven or twelve years of age, and in the Arctic regions at from sixteen to eighteen years. In England menstruation begins on an average at fifteen; but in girls born in India of European parents it generally begins at fourteen. Girls who have just begun to menstruate in England coming to Davos for the winter not infrequently cease to menstruate during the great cold, the function reappearing on return to a warmer climate or on the approach of summer. The cessation of the function is not attended with inconvenience or impairment of health.

The menstrual flow tends also to be rather more abundant in hot climates than in cold; and menorrhagia, due to lax and flabby tissue, is commonly benefited by a dry climate as cold as the patient can well bear.

Probably altitude in itself has no influence on menstruation, and acts only by virtue of the lower temperature that attends increased elevation.

The pain that not uncommonly occurs with menstruation is, I am inclined to think, rather less in dry than in damp climates. Cold, so far as I can judge, affects different people differently in this respect. In Davos in winter some women say they suffer more, and some less than in the lowlands. The influence of dryness and of temperature cannot readily be dissociated.

# CHAPTER LI

## DISEASES OF THE SKIN

Baths and mineral-water drinking cures now hold a very subordinate place in the treatment of diseases of the skin, and have never quite regained the position from which Hebra dislodged them.

Skin diseases of syphilitic origin are treated with advantage at resorts where mercurial inunction is in common use. Aix-la-Chapelle has a great reputation in this direction. The sulphur waters in general are resorted to by old syphilitic cases. Amongst the favourites, besides Aix-la-Chapelle, are Schinznach and Baden in Switzerland; Bagnères de Luchon, Cauterets, and Barèges in France; and Acqui in Italy.

Lassar, Brocq, Besnier, and Doyon, besides other well-known dermatologists, testify to the utility of baths in certain cases of chronic eczema. In no type of disease is the real nature of the case, as distinguished from the mere name, of greater importance. The treatment of eczema varies to infinity, according to its form and according to the person affected with it. If the disease depends on a gouty habit Royat, Vichy, Vittel, or Contrexéville waters internally are likely to be of use. Where there is constipation in robust plethoric persons the waters of Chatel-Guyon, Marienbad, Tarasp, or Carlsbad serve a good purpose. Only in chronic dry eczema of an indolent or sluggish type are baths to be recommended. In such cases the mild sulphur waters of Luchon, Cauterets, or Eaux Chaudes, are sometimes employed with advantage. Where arsenic is

indicated, as in obstinate dry eczema of a lichenoid type, La Bourboule or Mont Dore often yields excellent results. The continuous baths of Louèche-les-Bains are beneficial in some widely spread chronic dry eczemas, as well as in many other dry skin affections.

Chronic urticaria is also sometimes benefited by mineral waters and baths. Where the affection depends on a gouty disposition or on dyspepsia, the waters of Vichy, Vals, or Royat may be given. The simple thermal waters, such as those of Schlangenbad, Badenweiler, Plombières, Neris, Dax, and Ragatz, employed externally, are also occasionally of use.

A. E. Wright has suggested the internal use of chloride of calcium in urticaria, and he has recorded cases where it seemed to be useful. From this point of view the alkaline earthy waters might perhaps be employed with advantage.

In regard to skin diseases generally, the main principle is that baths are helpful where the skin is dry and harsh, and that as a rule the feebly mineralised waters are most commonly useful. Where the skin is irritable, baths generally aggravate the condition. In psoriasis, prurigo, and lichen, baths are a valuable adjunct to treatment; and there is often an advantage in administering arsenic or other drugs in mineral waters, when they are to be had in that form.

## CHAPTER LII

### GENERAL REMARKS

For the sake of emphasis one or two points already dwelt on may here be repeated. A few other considerations will be added—considerations so obvious as to require mention only because they are so often overlooked or forgotten.

In prescribing a climate or a mineral water we must first of all remember that the name of the disease never suffices to indicate the appropriate remedy. Whether a patient suffers from anæmia, diabetes, tuberculosis, heart disease, or dilatation of the stomach, the particular disease label is of little worth from a therapeutic point of view. A much broader outlook is essential: a general physiological stocktaking is called for. When the case is fully grasped our efforts must in the main be directed towards restoring disordered function. For this purpose the malady must be traced to its source. Anæmia, for example, may arise from loss of blood, from chronic suppuration, from insufficient supply of iron in the food, from the absorption of toxins as in constipation, from an infective process as in pernicious anæmia, from derangement of the blood-forming organs as in leukæmia and kindred ailments. To treat the case successfully we must deal with the cause. Reasons of this kind may lead us to prefer Harrogate, or Royat, or Levico, or Marienbad, or Homburg, or Tarasp. But that is not enough. We must examine whether the patient has some reserve vitality, with digestive, circulatory, respiratory, muscular, and renal systems likely to respond to a demand for a higher rate of tissue change, or whether he is a person

of low vitality with little power of response in the main organs of animal life. The choice between Schwalbach and St. Moritz would in some instances be determined largely by such considerations. Throughout the whole range of diseases influences of this kind must be weighed equally with the nature, intensity, and extent of the morbid condition before we can be fairly sure that our choice is right.

Certain extra-medical points must also be thought over before a decision is made to send a patient to a health resort.

Can the patient afford the treatment? If he can, is the advantage of such treatment so great as to outweigh its inconvenience and its greater cost in time, in money, and in business loss?

Then the mental and emotional nature of the patient must be regarded. Has the patient resources in himself, and will the proposed health resort harmonise with his disposition? Some persons like a quiet, some a gay place; some are content anywhere. Some prefer to travel alone, and are wearied or irritated by compulsory association with strangers; some prefer company. Some require with them a guardian or caretaker; others, a companion; others again, a nurse; and others, a servant. One man may not be happy without his wife; another may not know what peace of mind is unless she is away. All these points have to be taken into account; and they can generally be divined or ascertained without intrusion into private family history.

The patient's fitness for travel must, of course, be considered. Often he would be better in some distant climate; but we dare not subject him to the strain of getting there.

The environment when the patient reaches his destination must receive careful thought. Is competent medical guidance to be had, and skilful nursing, if need be? Are the food and the sanitary arrangements in all respects satisfactory? What is the daily life or spirit of the place—health, pleasure, sport, gambling, or all of these, side by side? Every resort has a more or less individual stamp,

almost a personality; and this *genius loci* leads people to visit again and again, and to regard with affection places where they managed to get well without brooding over their physical woes. A many-sided resort, like a many-sided man, can deal successfully with a great variety of people. The choice between resorts of the same climatic character or of equal therapeutic value will often be determined largely by our estimate of the patient's disposition or temperament.

At times the question arises whether a climate is to be found where the patient can earn his livelihood, settle permanently, or find a suitable channel for the investment of capital.

If these points and the principles laid down in the foregoing chapters are borne in mind, one will seldom go far wrong in the selection of climates or of mineral waters.

# LIST OF AUTHORITIES

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